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## A TENTATIVE SYNOPSIS OF THE HORNETS AND YELLOW-JACKETS (VESPINAE; HYMEN- OPTERA) OF AMERICA

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### INTRODUCTION

For several years past I have collected assiduously material for a monograph of the hornets and yellow-jackets of America and I have used every opportunity to study these insects in private and public collections. Although many thousands of specimens have passed through my hands, I do not feel that my present views concerning the relationships and variations of these wasps, are in any way final. Having been urged, however, by some of my correspondents to publish my results, I venture to present them in the form of a tentative synopsis.

The present paper should therefore not be regarded as a Monograph, but rather as an introduction to the study of the American Vespinae. It contains: (1) A key to the forms which may, in my opinion, be conveniently distinguished by names. (2) A condensed statement of the nomenclature and synonymy I have adopted, as a rule without entering into a discussion of the evidence on which my conclusions are based. (3) A summary of the distribution based upon the material I have studied. (4) A brief

account of the ethology, including unpublished observations, but without reviewing all published data.

My scheme of classification departs in many respects from that commonly used in this country. It is the outcome of an attempt to discover the relationships between the Old World and New World members of the subfamily, a line of investigation most likely to yield data of value to the zoögeographer. For, not only are the Vespinae the best defined of all the subfamilies of Diploptera; but they are also one of the few groups for which a northern common origin may most safely be assumed, since they are nowadays almost restricted to the Northern Hemisphere and are not indigenous to the Neotropical and Ethiopian Regions. In this connection it may be well to point out that, in my opinion, the Vespinae show no close relations to any of the other subfamilies of social wasps, least of all to the cosmopolitan subfamily Polistinae.

In tracing relationships I have used the same method as in my other papers dealing with Diploptera. Without entering into any formal discussion, I may state that I regard structural characters as of primordial value, and differences or similarities in color or pattern as of secondary importance. Only such forms are given specific rank as are separable by means of reliable structural peculiarities in at least one of the sexes. Groups of specimens differing from one another only in coloration, I consistently treat as forms of a single species, the first described being regarded as the "typical form," the others as "varieties." Although the term "variety" is non-committal, since it makes no implication as to the true genetic significance of the particular form in question, I believe, nevertheless, that "color varieties" are genetically subordinated to "structural species." I hold that, in the Diploptera at any rate, of the several slow or rapid changes which the organism undergoes in the process of evolution, those that affect color will occur most readily and will also be the least stable; hereditary modifications of structure, on the other hand, are more difficult to produce, but are more permanent once they have appeared. Frequently there is no apparent correlation between the evolutionary changes affecting the color and those influencing structure. Finally, color is more readily affected by environmental factors than structure.

In an earlier paper (1930, Bull. Brooklyn Ent. Soc., XXV, pp. 59-70) I have fully discussed the subfamily, generic and subgeneric characters of the Vespinae, as well as the general distribution of



the group. The discovery of additional characters has, however, necessitated a revised account of the subgeneric peculiarities of *Vespula*, proper, and *Dolichovespula*.

In the course of my studies I have perused with care all publications dealing with North American Vespinae, especially those of H. de Saussure (1853; 1857), J. McFarland (1888), H. W. Lewis (1897), R. du Buysson (1903-1905), and F. W. L. Sladen (1918). Lack of space precludes my entering into any historical discussion of previous work.

*Male External Genitalia, or Terminalia, of the Vespinae.*—Since the shape of the male terminalia affords, in my opinion, the most reliable specific characters in the subfamily Vespinae, it is necessary to consider these structures somewhat in detail. In order to study them no special technique is called for. The voluminous apparatus can readily be extracted with a pin, after relaxing the specimen in case of dry material. The several parts are then gently spread out so as to permit a full view of their shape.

There is as yet no agreement among the authors regarding the homology of the male external genitalia of the Vespinae and the names to be applied to the several parts. For the purpose of this paper I have borrowed most of my terminology from E. Zander's account (1900, *Zeitschr. Wiss. Zool.*, LXVII, 3, pp. 461-489, Pl. XXVII).

We may regard the male genitalia as consisting of three groups of structures, which envelop the *ductus ejaculatorius* like a sheath or cloak.

1. At the base of the entire apparatus lies, ventrally, a small half-ring, the *cardo* (Fig. 1, *ca*), Dufour's "*pièce basilaire*," which connects the genitalia with the abdomen. Superficially it appears to be divided, on the ventral side, by a median, longitudinal depression.

2. Dorsad and laterad of the *cardo* are placed two pairs of large appendages, the *valvae*, which can move on each other and in the *cardo*.

2*a*. The external pair of strong lateral pieces are the *valvae externae* (Fig. 1, *ve*), Dufour's "*branches du forceps*" (a term adopted by R. du Buysson) and Kluge's and Sladen's "*stipites*." I here restrict the term *stipites* (singular, *stipes*; Fig. 1, *st*) to the external portion of the *valvae externae*, which is heavily sclerotized, broad and very convex, so that its inner concavity normally encloses most of the remaining parts of the genitalia. At the truncate apex

of each stipes one may as a rule distinguish an *outer edge* (Fig. 1, *oe*), an *upper (or dorsal) inner edge* (Fig. 1, *uie*), and a *lower (or ventral) inner edge* (Fig. 1, *lie*), the shape of which is often characteristic. Internally each stipes bears a scale-like or lobe-like appendage, which I call the *squama* (Fig. 1, *sq*), R. du Buysson's "*lobe de la branche du forceps*," Zander's "*mediale Schuppe*."

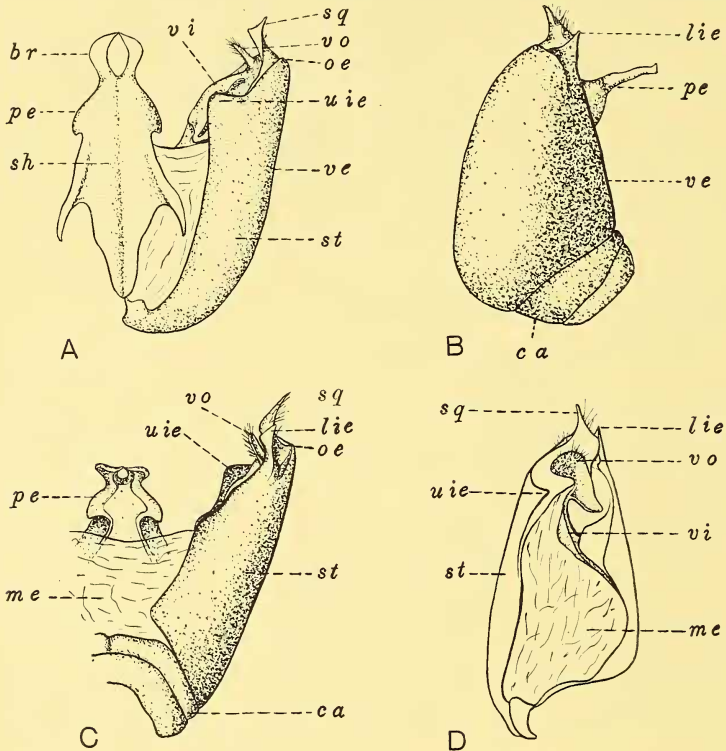


Fig. 1. Male external genitalia of *Vespula maculata* (Linnaeus): A, dorsal view; B, side view of left valva externa; C, ventral view; D, inner view of right valva externa, showing valva interna (dotted area).—*br*, branches of penis; *ca*, cardo; *lie*, lower inner edge of stipes; *me*, connecting membrane; *oe*, outer edge of stipes; *pe*, penis; *sh*, shaft of penis; *sq*, squama of valva externa; *st*, stipes of valva externa; *uie*, upper inner edge of stipes; *ve*, valva externa; *vi*, valva interna; *vo*, volsella of valva interna.

The squama is closely pressed against or ensheathed by the lower inner edge of the stipes, beyond the tip of which it generally protrudes.

2b. The internal pair of more slender and much smaller and softer pieces are the *valvae internae* (Fig. 1, *vi*), Dufour's and R. du Buysson's "*volselles*," Kluge's "*sagittae*." Their apical portion appears to be divided into three lobes, one of which generally forms a free, finger-shaped flap, often densely hairy or brush-like and protruding near the squama. I propose to restrict the term *volsella* (Fig. 1, *vo*) to this protruding lobe; Birula calls it the "*penicillum*." R. du Buysson's "*tenette*" seems to apply to the lobe at the base of the volsella, usually folded inward.

3. Dorsally and broadly attached to the valvae by means of a soft, extensible membrane (Fig. 1, *me*) is a median piece, the *penis* (Fig. 1, *pe*), Dufour's "*fourreau de la verge*," R. du Buysson's "*crochets*," Kluge's "*spatha*," Sladen's "*sagittal piece*" or "*sagittae*." Originally it consisted of a pair of sclerotized rods, which in certain species of Vespinae are completely fused throughout, while in others they are partly free, forming two *apical branches* (Fig. 1, *br*). The basal portion, or *shaft* (Fig. 1, *sh*), may be slender, equally wide throughout, or triangular. The shape of the penis is distinctive in most species.

I have not attempted to give a complete description of the genitalia of every species, nor have I indicated all the peculiarities of these organs that might be found of specific value. In my key I have made use of those peculiarities that seemed to be most reliable as well as most readily appreciated. A comparison of the drawings will disclose other differences, some of which may be equally valid, while others are probably unreliable. I must particularly warn against relying too much on the aspect of the squama of the valva externa and the volsella of the valva interna. These parts are much less sclerotized than either the stipes or the penis, so that they may be curved or twisted in various ways, their appearance being often very deceptive.

*Nomenclature.*—The generic and subgeneric names used throughout this essay are those of my former paper (1930). Meanwhile, Dr. H. Bischoff, of Berlin, has published an important contribution to the knowledge of the Palearctic Vespinae,<sup>1</sup> in which he adopts a nomenclature differing in many respects from my own. The divergence of opinion in this case seems to show once more the utter futility of hoping for stability if one follows an intricate

<sup>1</sup> Bischoff, H. 1931. Zur Kenntnis der Gattung *Pseudovespa*. Sitzungsber. Ges. Naturf. Fr. Berlin, (1930), pp. 329–346. I am very much indebted to Dr. Bischoff for a copy of this paper.

system of rules, recommendations and opinions, which invariably leads to mere casuistry.

The following are the points in which Dr. Bischoff's system differs from that adhered to in this paper.

(1) In accordance with Opinion 79 of the International Commission of Nomenclature, Bischoff refuses to regard Lamarek's (1801) citation of *Vespa crabro* Linnaeus as an example of *Vespa* Linnaeus, as a valid designation of the genotype. Hence he accepts Latreille's (1802) selection of *Vespa vulgaris* Linnaeus as the type. *Vespula* Thomson (1869) thus becomes a synonym of *Vespa*, since it included *V. vulgaris*.<sup>2</sup>

(2) If the generic term *Vespa* is no longer available for the "Hornissen" or "hornets,"<sup>3</sup> these large wasps should go under the name *Macrovespa* Dalla Torre (Genotype: *Vespa crabro* Linnaeus).

(3) Bischoff refuses to admit Ashmead's (1902) designation of *Vespa austriaca* Panzer as the genotype of *Vespula* Thomson, because (a) *Vespa austriaca* was no longer available, having been eliminated from *Vespula* when Schmiedeknecht (1881) proposed the generic name *Pseudovespa* for that species;<sup>4</sup> and (b) Ashmead erroneously attributed a long oculo-malar space to the group in which he included *V. austriaca*.

(4) Bischoff admits *Pseudovespa* to full generic rank. He includes in it all inquiline wasps, which have lost the worker caste. He divides it, however, into two subgenera: *Pseudovespa* proper, with a short oculo-malar space, includes only the genotype, *P. austriaca*; while two inquiline forms with a long oculo-malar space,

<sup>2</sup> Stiles and Hassall (1928, U. S. Publ. Health Serv., Hyg. Lab. Bull. 150) apparently accept as binding Latreille's (1810) designation of *Vespa crabro* Linnaeus as the type of *Vespa*, in accordance with Opinion 11 of the International Commission on Nomenclature.

<sup>3</sup> In the British Isles the term "hornet" is correctly used for *V. crabro* only, and therefore corresponds to the German "Hornisse" and the French "frelon." But in America, where true hornets were originally unknown, the name is commonly applied to some of the larger indigenous wasps, such as *Vespula maculata*. Moreover, in some parts of the United States, where the Vespinae are relatively scarce, the term hornet is sometimes used even for species of *Polistes*.

<sup>4</sup> This is contrary to Opinion 62 of the International Commission on Nomenclature, which states that "type species of other genera are not excluded from consideration in the selection of the type of a genus."

*P. adulterina* (R. du Buysson) and *P. omissa* Bischoff, form the subgenus *Pseudovespula* Bischoff (Subgenotype: *Vespa norwegica* var. *adulterina* R. du Buysson, 1905).

Entomologists who feel inclined to accept Dr. Bischoff's nomenclature rather than my own will have to arrange the North American Vespinae as follows:

1. *Macrovespa* DallaTorre will include *M. crabro* (Linnaeus) only.

2. *Vespa* Linnaeus (Syn.: *Vespula* Thomson) will comprise two subgenera:

2a. *Vespa*, proper, with *V. vulgaris* Linnaeus, *V. maculifrons* R. du Buysson, *V. pennsylvanica* H. de Saussure, *V. rufa* Linnaeus, *V. squamosa* Drury, and *V. sulphurea* H. de Saussure.

2b. *Dolichovespula* Rohwer, with *V. norwegica* Fabricius, *V. arenaria* Fabricius, and *V. maculata* Linnaeus.

3. *Pseudovespa* Schmiedeknecht will comprise two subgenera:

3a. *Pseudovespa*, proper, with *P. austriaca* (Panzer).

3b. *Pseudovespula* Bischoff, with *P. adulterina* (R. du Buysson).

#### KEY TO AMERICAN VESPINAE

1. Head very large, swollen behind the eyes, with wide outer orbits and long vertex; posterior ocelli only a little farther from the eyes than from each other, placed close to a line joining the middle of the upper lobes of the eyes and four to six times as far from the occipital margin as from each other. Inner orbits distinctly farther apart at the clypeus than on the vertex. Oculo-malar space short but distinct, about the length of the penultimate antennal segment in queen and worker. Clypeus of queen and worker slightly wider than long, uniformly covered with coarse punctures, its apical margin with a shallow, broad emargination. Sides of pronotum with a vertical carina over the entire upper portion. All tibiae with long, erect hairs on the upper face. Male with a pair of conspicuous longitudinal ridges (tyloides) on the under side of most of the segments of the flagellum; shaft of penis wide distally, the apical branches separated by a deep and broad, subcircular notch. Large species (20 to 30 mm. in total length), extensively reddish-brown, the head partly orange, the abdominal tergites with apical, dull yellow margins, very narrow on the first, much wider and more or less notched on the remainder; the last tergite mostly yellow (*Vespa*) ..... *Vespa crabro* Linnaeus.



- Head not unusually large, not swollen behind the eyes, with narrow outer orbits and short vertex; posterior ocelli on a line close to, or tangent with, the supraorbital line and at most as far from the occipital margin as from the eyes. Smaller species, at most 20 mm. in total length (*Vespula*)... 2.
2. Oculo-malar space short, at most half the length of the penultimate antennal segment in male, much shorter in queen and worker. Vertical carina of the sides of pronotum either obsolete or faintly marked in the lower portion only. Male: branches of penis completely fused throughout, the apical portion saddle-shaped or spoon-like. (Subgenus *Vespula* proper) .....3.
- Oculo-malar space long, nearly as long as, or longer than, the penultimate antennal segment in male, queen and worker. Posterior orbit separated from the occiput in its upper half only, by a suture which is sometimes obsolete. Vertical carina of the sides of pronotum complete, well-developed in the upper portion. Upper face of tibiae with long, erect hairs over the whole length, especially noticeable on the hind legs. Male: branches of penis not completely fused, the apical portion deeply bifid; seventh tergite uniformly convex throughout. (Subgenus *Dolichovespula*) ..... 23.
3. Upper side of hind tibiae bearing long, erect hairs scattered over the whole length. Posterior orbit separated from the occiput by a ridge in its upper half only. Postscutellum impunctate. Black, abundantly marked with yellow; mesonotum without yellow stripes. Erect hair of first tergite black. Male: seventh tergite uniformly convex throughout, not notched at apex; penis broad, ending in a curved, saddle-shaped expansion, the apex truncate. Female: apical margin of clypeus with produced and somewhat raised, sharp lateral edges. No workers .....*Vespula austriaca* (Panzer).
- Upper side of hind tibiae without erect hairs, rarely with a few long hairs at the extreme base. Workers present .....4.
4. Mesonotum with two broad, longitudinal, curved, yellow stripes, not quite reaching the anterior and posterior margins. Posterior orbit separated from the occiput by a ridge in its upper half only. Male: seventh tergite evenly convex throughout, not notched at apex .....5.
- Mesonotum entirely black or at most with two very short, lengthened, pale spots close to the scutellum ..... 6.
5. Second cubital cell of fore wing obliquely triangular, its lower side nearly twice as long along the cubitus as the third cubital cell; the distance between the tip of the second recurrent and the second intercubitus equal to or slightly over the length

of the third cubital cell along the cubitus. Queen, worker and male black with numerous bright yellow markings. Male: apex of penis with a horseshoe-shaped notch, seen from above .....*Vespula sulphurea* (H. de Saussure).

Second cubital cell of fore wing more evenly triangular, its lower side not or slightly longer along the cubitus than the third cubital cell; the distance between the tip of the second recurrent and the second intereubitus much shorter than the length of the third cubital cell along the cubitus. Queen mostly orange, with black margins to the abdominal segments; worker and male black with numerous yellow markings. Male: apex of penis without horseshoe-shaped notch, slightly curved inward, seen from above.

.....*Vespula squamosa* (Drury).

6. Queens and workers ..... 7.  
Males ..... 15.

7. Posterior orbit separated from the occiput by a fine ridge or raised suture in its upper half or two-thirds only, its hind edge completely rounded off over some distance above the base of the mandible. First abdominal segment narrowed anteriorly, the horizontal area of the tergite slightly depressed behind the edge. Long, erect pilosity of first abdominal tergite black ..... 8.

Posterior orbit divided from the occiput by a fine ridge over its entire length, down to the base of the mandible.<sup>5</sup> First abdominal segment equally broad throughout, the horizontal area of the tergite not at all depressed. Long, erect pilosity of first abdominal tergite mostly pale, grayish or yellowish ..... 13.

8. Pale markings white or ivory-white ..... 9.  
Pale markings yellow ..... 10.

9. First and second tergites and sternites of the abdomen marked more or less with rufous spots.

.....*Vespula rufa* var. *intermedia* (R. du Buysson).

Abdomen without rufous markings, only black and white. Apical white fascia of second tergite narrower than the following; that of the first tergite very narrow and widely interrupted, or absent.

.....*Vespula rufa* var. *consobrina* (H. de Saussure).

10. First and second tergites and sternites of abdomen more or less marked with rufous. (Not in North America).

.....Typical *Vespula rufa* (Linnaeus).

Abdomen marked with black and yellow only ..... 11.

<sup>5</sup> When the pale color of the orbit extends over the under side of the head, the fine ridge is often difficult to see and may be readily overlooked.

11. Apical yellow fasciae of third, fourth and fifth tergites very wide, often more or less enclosing black lateral spots; that of the second tergite conspicuously narrower and gradually widened toward the sides; second tergite without free, yellow spots. Clypeus with three elongate, black spots placed more or less in a triangle below the middle, sometimes fused into a three-cornered or anchor-shaped spot.

*Vespula rufa* var. *vidua* (H. de Saussure).

Apical fasciae of third to fifth tergites not conspicuously wider than those of the second and first; the second tergite as a rule extensively yellow or with free yellow spots .....12.

12. Pronotum and abdomen very extensively yellow; most of the tergites yellow, with narrow black bases triangularly produced in the middle and with small black, lateral spots. Clypeus as a rule with three minute black dots, often barely indicated .....*Vespula rufa* var. *atopilosa* (Sladen).

Yellow markings of pronotum and fasciae of abdomen moderately wide or narrow; second tergite usually with free, yellow, lateral spots. Clypeus sometimes with a broad, longitudinal black band, often anchor-shaped or expanded below.

Western *Vespula rufa* var. *sladeni* J. Bequaert and Eastern *Vespula rufa* var. *acadica* (Sladen).

13. Darker species, with the black color predominating. First tergite of abdomen as a rule black with an apical yellow fascia, sometimes narrowed in the middle. Yellow hind margin of pronotum usually even, parallel-sided. Propodeum without yellow spots. Clypeus with a broad, longitudinal black stripe, often anchor-shaped; outer orbits sometimes with a black spot. Black stripes connecting antennal sockets with vertex gradually broadened above. Antennal scape black. Tibiae sometimes spotted with black. Apical margin of mandible straight between the small basal notch and the first tooth, the latter forming a right angle. Eastern and Western, but of more northern distribution.

*Vespula vulgaris* (Linnaeus).

Lighter species, much more extensively marked with yellow, especially on the first tergite. Yellow hind margin of pronotum usually widened outwardly. Clypeus rarely with a short, median, black stripe, as a rule with one or three black spots; outer orbits yellow throughout. Black stripes above antennal sockets usually constricted above or completely separated from the black vertex and sometimes almost absent ..... 14.

14. Apical margin of mandible distinctly curved inward between the small basal notch and the first tooth, the latter forming

- an acute angle. Antennal scape entirely yellow in front. Propodeum almost always with large yellow spots. Western ..... *Vespula pennsylvanica* (H. de Saussure).  
Apical margin of mandible straight between the small basal notch and the first tooth, the latter forming a right angle. Antennal scape black or at most with traces of yellow in front. Propodeum usually without yellow spots, more rarely spotted. Eastern ..... *Vespula maculifrons* (R. du Buysson).
- 15. Seventh abdominal tergite uniformly convex throughout; 7th tergite and sternite broadly rounded off and entire at apex. Genitalia: penis very broad throughout, the apical portion forming a subtruncate, saddle-shaped club ..... 16.  
Disk of seventh abdominal tergite more or less depressed or saddle-shaped; both 7th tergite and 7th sternite truncate or slightly notched at apex. Genitalia: penis narrowed into a slender shaft, which ends in a spoon-shaped, subcircular or oval expansion ..... 21.
- 16. Pale markings yellow ..... 17.  
Pale markings white or ivory-yellow ..... 20.
- 17. First and second tergites and sternites of abdomen more or less marked with rufous. Clypeus with an irregular, black, longitudinal fascia. (Not in North America).  
typical *Vespula rufa* (Linnaeus).  
Abdomen marked with black and yellow only ..... 18.
- 18. Apical yellow fasciae of third to sixth tergites very wide; that of the second conspicuously narrower and gradually widened toward the sides; second and succeeding tergites without free, yellow spots ..... *Vespula rufa* var. *vidua* (H. de Saussure).  
Apical yellow fasciae of third to sixth tergites not conspicuously wider than those of the second and first ..... 19.
- 19. Abdomen very extensively yellow, much as in the queen. Apical yellow area of second tergite very wide, as a rule enclosing a pair of black spots; the basal black area without completely free yellow spots.  
*Vespula rufa* var. *atopilosa* (Sladen).  
Apical yellow area of second tergite narrow, rarely enclosing black spots; the basal black area often with two yellow spots, either entirely free or more or less united with the apical fascia.  
Western *Vespula rufa* var. *sladeni* J. Bequaert  
and Eastern *Vespula rufa* var. *acadica* (Sladen).
- 20. First and second tergites of the abdomen more or less marked with rufous spots.  
*Vespula rufa* var. *intermedia* (R. du Buysson).

Abdomen without rufous markings, only black and white. Apical fasciae of first and second tergites narrower than the others; that of the first more or less interrupted in the middle, or much reduced, or absent. Clypeus with an irregular, black, longitudinal band or cross in the apical two-thirds.

*Vespula rufa* var. *consobrina* (H. de Saussure).

21. Genitalia (Fig. 3A): shaft of penis without teeth or wing-like expansions at the base of the terminal spoon (ventrally); the spoon itself strongly concave and almost cup-shaped, heart-shaped in outline from above, the margin curved inward and with the proximal edges expanded close to the shaft (dorsally); upper inner edge of stipes, seen from above, short and wide, broadly truncate. Disk of seventh tergite very gradually sloping from the convex base to the flattened apical area, the apex as a rule not emarginate (at most with a slight inward curve). Western species.

*Vespula pensylvanica* (H. de Saussure).

Genitalia (Fig. 2A): shaft of penis with a sharp tooth on each side, close to the base of the terminal spoon (placed ventrally and directed basad); the spoon itself slightly concave, sub-circular in outline seen from above, with the apex evenly rounded and the proximal edges not expanded dorsally near the shaft; upper inner edge of stipes, seen from above, very narrow, digitate and obtusely pointed ..... 22.

22. Disk of seventh tergite abruptly depressed at its basal third, the convex base forming in profile a sharp angle or notch with the flattened apical area; the apex itself not or hardly emarginate (Fig. 2D and E). Eastern species.

*Vespula maculifrons* (R. du Buysson).

Disk of seventh tergite gradually sloping from the convex base to the flattened apical area; the apex as a rule with a distinct, though shallow emargination (Fig. 2B and C). Eastern and Western, but of more northern distribution.

*Vespula vulgaris* (Linnaeus).

23. Queens and workers ..... 24.  
 Males ..... 29.  
 24. Pale markings yellow or dirty-yellow ..... 25.  
 Pale markings white or ivory-white ..... 27.  
 25. Lateral angles of anterior margin of clypeus very prominent, sharply set off and somewhat raised. Outer orbit rounded off behind, nowhere separated from the occiput by a distinct suture. Oculo-malar space about one-half the length of the scape. Flagellum of antennae entirely black. Yellowish hind margin of pronotum produced far downward along the anterior vertical carina; the apical fasciae of first and second



- tergites wide and not or hardly interrupted in the middle (narrow and broadly interrupted in the var. *arctica*). No workers ..... *Vespula adulterina* (R. du Buysson).
- Lateral angles of anterior margin of clypeus broadly rounded, not raised. Outer orbit with a suture or ridge in the upper third or half, separating it from the occiput. Oculo-malar space about two-thirds the length of the scape. Yellow color bright. Flagellum of antennae more or less dirty-yellowish on the under side. Workers present ..... 26.
26. Yellow margins of first and second tergites deeply notched or more or less interrupted on the middle line. Yellow hind margin of pronotum as a rule produced downward along the anterior, vertical carina. Outer orbits yellow throughout. Anterior truncate margin of clypeus rather deeply curved inward ..... *Vespula arenaria* (Fabricius).
- Yellow margins of first and second tergites narrow, continuous, not notched in the middle. Yellow hind margin of pronotum not produced downward or with a slight extension. Outer orbits as a rule partly black, more rarely entirely yellow. Anterior truncate margin of clypeus shallowly curved inward ..... *Vespula norvegica* var. *norvegicoides* (Sladen).
27. Lower half of sides of pronotum (between humeral calli and coxae) finely, transversely striate; lower half of propodeum likewise with an irregular oblique striation, more distinct apically, where it delimits a depressed, semi-circular area. Flagellum of antennae pale ferruginous or dirty-yellow on the under side. Pale hind margin of pronotum extending downward along the anterior, vertical carina. First two tergites of abdomen entirely black; the third with a transverse, white, apical spot on each side (small in worker); the three following extensively white.  
*Vespula maculata* (Linnaeus).
- Lower half of sides of pronotum and propodeum punctate, not striate. Basal tergites of abdomen marked with white.....28.
28. Pale hind margin of pronotum narrowed anteriorly, not produced downward along the vertical, anterior carina. Flagellum of antennae often more or less yellowish on the under side. White margins of first and second tergites continuous and wide throughout. Workers present and generally with a pair of ferruginous or rufous spots on the second tergite (these spots never present in the queen); anterior, truncate margin of clypeus moderately projecting in the queen, with low, broadly rounded lateral angles. Outer orbit with a suture or ridge in the upper third, separating it from the occiput ..... *Vespula norvegica* var. *marginata* (Kirby).

Pale hind margin of pronotum widened anteriorly, showing at least a tendency to extend downward along the vertical, anterior carina. Flagellum of antennae entirely black. Pale margins of first and second tergites either very wide and hardly interrupted in the middle (typical *adulterina*) or narrow and broadly interrupted or even absent on the first (var. *arctica*). Anterior, truncate margin of clypeus much projecting, with prominent, raised lateral angles. Outer orbit rounded off behind, nowhere separated by a distinct suture from the occiput. No workers.

*Vespula adulterina* and its var. *arctica* Rohwer.

29. Most of the segments of the flagellum (beginning with the third) with conspicuous, longitudinal welts or ridges (tyloides) on the under side. Lower sides of pronotum and lower half of propodeum finely striate. Seventh sternite deeply, semi-circularly emarginate at apex, with sharp lateral edges. Penis very wide, expanded in its apical third, the terminal branches tong-shaped, flat and broad, curved inwardly, the sharp points touching each other. Upper inner edge of stipes bluntly rounded off, seen from above. Pale markings white, much as in the queen, but the apical margin of the first tergite often very narrowly white; flagellum pale ferruginous or dirty-white on the under side.

*Vespula maculata* (Linnaeus).

Flagellum either without tyloides, or with short ridges on the under side of the last five or six segments. Lower sides of pronotum and propodeum punctate. Seventh sternite not deeply emarginate. Penis of a different shape ..... 30.

30. Posterior orbit slightly wider than usual, either rounded off posteriorly or very faintly divided from the occiput by a suture in its upper part. Flagellum of antennae entirely black, without tyloides (the terminal segment alone with a trace of a longitudinal welt near the base). Oculo-malar space distinctly shorter than the scape. Anterior margin of clypeus strongly projecting, rather angular at the sides. Penis: basal two-thirds triangularly narrowed toward apex, the shaft with a dorsal longitudinal crest, the terminal branches slender and almost straight. Upper inner edge of stipes forming a slight, blunt angle, seen from above ..... 31.
- Posterior orbit of the usual width, separated from the occiput by a distinct ridge or raised suture in its upper third. Flagellum of antennae with short ridges on the under side of the last five or six segments ..... 32.
31. Markings yellow or yellowish-white; apical fasciæ of the abdomen wide and deeply trisinate; pale hind margin of

pronotum extending far down along the vertical, anterior carina; postscutellum and seventh tergite as a rule spotted with yellow; clypeus generally yellowish with a black, median, elongate spot, sometimes very small.

*Vespula adulterina* (R. du Buysson).

Markings white or ivory-white; apical fasciæ of the abdomen narrow, those of the first and second tergites often reduced or interrupted in the middle; pale hind margin of pronotum showing only a tendency to extend downward along the vertical, anterior carina; postscutellum and seventh tergite as a rule unspotted; clypeus generally with a black, longitudinal stripe, which is sometimes quite broad.

*Vespula adulterina* var. *arctica* Rohwer.

32. Last five segments of flagellum each with a short ridge (or tyloide) near the base. Markings white or dirty-white; second tergite usually with a pair of ferruginous spots; flagellum as a rule entirely black. Genitalia as in *norvegicoïdes* ..... *Vespula norvegica* var. *marginata* (Kirby).

Last six segments of flagellum each with two short ridges (or tyloides), one near the base, the other toward the apex. Markings yellow; second tergite without ferruginous spots; flagellum more or less extensively dirty-yellowish on the under side, rarely almost wholly black ..... 33.

33. Upper inner edge of stipes rectangularly produced, the blunt angle rounded off, seen from above. Penis broadly triangular, the shaft with a fine dorsal, longitudinal ridge, the apical branches flat and broad, with curved outer and straight inner margins, and with blunt points. Yellow markings much as in the queen; apical fascia of first tergite deeply notched or interrupted on the middle line; yellow hind margin of pronotum continued downward along the vertical carina; under side of flagellum extensively testaceous; posterior orbits with a continuous yellow band.

*Vespula arenaria* (Fabricius).

Upper inner edge of stipes slightly produced and broadly rounded off seen from above. Penis more narrowly triangular, the shaft with a dorsal, longitudinal crest, the apical branches tong-shaped, more slender, with curved outer and inner margins and sharp, long points. Yellow markings as in the queen; apical fascia of first tergite continuous in the middle; hind margin of pronotum not extended along the vertical carina; under side of flagellum slightly testaceous; posterior yellow orbits as a rule interrupted by a black median spot.

*Vespula norvegica* var. *norvegicoïdes* (Sladen).

*Vespa* Linnaeus

The genus *Vespa*, as here delimited, contains only the larger or true "hornets." Its characters and distribution have been discussed elsewhere (1930, Bull. Brooklyn Ent. Soc., XXV, p. 64). There are no indigenous species in America, although some of them have been introduced occasionally into the New World. Thus far only one species, *V. crabro* Linnaeus, has become naturalized in the eastern United States.

I have seen a queen of another species, *Vespa orientalis* Linnaeus, said to have been taken a few years ago by Mr. Geo. F. L. Moetz, at Williams Bridge Road, The Bronx, New York City. There is, however, as yet no evidence that this hornet has become established in North America. There are in the literature some scattered records of *Vespa orientalis*, *Vespa tropica* Linnaeus (= *V. cincta* Fabricius), and its var. *affinis* Fabricius, having been taken in the American tropics, evidently as accidental introductions. Moreover, some of these records may be based on erroneous labelling of specimens.

1. *Vespa crabro* Linnaeus.

*Vespa crabro* Linnaeus, 1758, Syst. Nat., 10th Ed., I, p. 572 (Europe).

The common hornet of Europe occurs over most of the Palearctic Region, south of Lat. 62°. It was introduced into North America by man between 1840 and 1860. According to H. de Saussure (1898, Ent. News, IX, p. 145), it was caught for the first time in the eastern United States in 1854; but J. Angus, in 1871, stated that in his vicinity (West Farms, New York) this hornet had been common for the past 25 years. At present it is thoroughly naturalized in Long Island, Staten Island, the southern part of New York State (as far north as Hudson, Nyack, West Point, and Poughkeepsie), northern New Jersey (as far south as Princeton and Riverton), and southwestern Connecticut (as far east as Milford and New Haven). Specimens have also been taken near Philadelphia, in Maryland and in Delaware. Published records from Illinois, Northern and Southern Carolina, and New Orleans are open to question.<sup>6</sup>

<sup>6</sup> The finding of a lilac branch, apparently gnawed by a wasp, in the Chicago area, as recorded by Bromley (1931, Jl. New York Ent. Soc., XXXIX, p. 124), is in my opinion insufficient proof of the occurrence of *V. crabro* in that region, since other animals may attack branches in a similar fashion. Moreover, *Vespula maculata* has been reported by Meehan (1878, Proc. Ac. Nat. Sci. Phila-

In the Palearctic Region, *V. crabro* is represented by a number of color forms (or races), as I have shown in a paper recently published in *Konowia* (1931, VIII, pp. 101-109). The form established in North America is the var. *germana* Christ [= *Vespa crabro germana* Christ, 1791, *Naturgesch. Insekten Bienen, Wespen u. Ameisengeschl.*, p. 215, Pl. XVIII, fig. 3; *Vespa crabro vulgata* Birula, 1925, *Arch. f. Naturgesch.*, XC, (1924), Abt. A, Heft 12, p. 100], of western and central continental Europe. In this form the thorax is abundantly marked with russet, the queen having at least two longitudinal russet stripes on the mesonotum.

*V. crabro* builds very large nests in some sheltered situation, preferably in hollow trees, under the roof of attics, porches or open sheds, in holes of rocks, in caves, or even in underground cavities. More freely exposed, aerial nests are completely enclosed by an envelope of very brittle paper. When the nest is placed inside a small cavity, as, for instance, in a hollow tree, the outer paper cover may be either completely lacking or only partly present. There are many accounts of the habits of this hornet, beginning with those of Réaumur (1742) and Degeer (1771). In North America they have been observed by J. Angus (1871), W. Beutenmüller (1898), J. A. Grossbeck (1908), E. P. Felt (1915), W. T. Davis (1924; 1925), and E. N. Cory (1931). A queen found hibernating at Picton, New Jersey, March 28, 1920, had the plaited wings tucked away between the hind legs and the lower sides of the abdomen, as is customary for the hibernating females of the Vespinae.

#### *Vespula* C. G. Thomson

A more intensive study of the several species of *Vespula* has disclosed additional characters separating the two subgenera, *Vespula* proper, and *Dolichovespula*. That these two subgenera represent natural groups, and not artificial products of the taxonomic mind, I have not the slightest doubt.<sup>7</sup>

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delphia, p. 15) as stripping off the bark of young branches. Cory's record from Illinois (1931, *Jl. Econ. Ent.*, XXIV, p. 50) also was not based upon specimens, but upon erroneous information. There are at present no Illinois specimens of *V. crabro* at the U. S. National Museum, at the State Natural History Survey of Illinois, and at the Field Museum of Natural History.

<sup>7</sup> Attention should be called to a very unfortunate error in the characterization of the subgenus *Vespula* proper, in my earlier paper (1930, *Bull. Brooklyn Ent. Soc.*, XXV, p. 67). The statement "tibiae as a rule with long hairs," should have read "tibiae as a rule *without* long hairs."



In each subgenus, the several species fall in a number of subgroups, which may be briefly mentioned.

1. Subgenus *Vespula proper*.

A. Subgroup of *Vespula vulgaris*.—Posterior orbit generally separated from the occiput over its entire length by a fine ridge, which as a rule reaches the base of the mandible (less distinct in the male). Male: disk of seventh tergite more or less depressed; shaft of penis slender, the two branches fused throughout and forming an apical, subcircular or heart-shaped spoon; stipes with a strong, inwardly projecting upper inner edge; volsella of valva interna very long, finger-shaped, densely hairy, extending to the tip of the squama of the valva externa. This subgroup contains *V. vulgaris* (Linnaeus), *V. germanica* (Fabricius), *V. maculifrons* (R. du Buysson), *V. pensylvanica* (H. de Saussure), *V. lewisii* (P. Cameron, 1903) (= *Vespa japonica* H. de Saussure, 1858; not of Radoszkowsky, 1857; *Vespa saussurei* W. A. Schulz, 1906), and *V. koreensis* (Radoszkowsky).

B. Subgroup of *Vespula rufa*.—Posterior orbit incompletely separated from the occiput, the ridge never reaching the base of the mandible. Male: disk of seventh tergite evenly convex; shaft of penis broad, the two branches fused throughout into a broad, elongate plate, hardly widened at the apex where it forms a subtruncate saddle-shaped piece; stipes with the upper inner edge not or very slightly projecting; volsella of valva interna short and slender, almost bare, not reaching the tip of the squama of the valva externa. This subgroup comprises *V. rufa* (Linnaeus), *V. austriaca* (Panzer), *V. structor* (F. Smith), *V. squamosa* (Drury), and *V. sulphurea* (H. de Saussure).

2. Subgenus *Dolichovespula*.

C. Subgroup of *Vespula norvegica*.—Lower sides of pronotum and propodeum punctate. Male: flagellum of antenna with at least traces of welts (tyloides) on the under side; seventh sternite not deeply emarginate; branches of penis incompletely fused, the basal shaft forming an elongate triangular piece, gradually tapering toward the two parallel, somewhat curved and flattened apical rods, which in profile are shaped like a hawk's bill with the hook turned upward; stipes with the upper inner edge slightly projecting, broadly rounded; volsella of valva interna long and broad, densely hairy, extending fully to the tip of the squama of the valva externa. This subgroup comprises *V. norvegica* (Fabricius), *V. arenaria* (Fabricius), and *V. adullterina* (R. du Buysson).

D. Subgroup of *Vespula sylvestris*.—Lower sides of pronotum and propodeum punctate. Male: flagellum of antennæ without tyloides; seventh sternite not deeply emarginate; branches of penis incompletely fused, the basal shaft narrowly triangular, passing very gradually into the two apical rods, which are parallel, closely appressed, thickened and very obtuse in profile; stipes with a strong upper inner edge, projecting apicad; volsella of valva interna short and moderately slender, nearly bare, much shorter than the squama of the valva externa. This subgroup contains only *V. sylvestris* (Scopoli) and its inquiline derivative *V. omissa* (Bischoff).<sup>8</sup>

E. Subgroup of *Vespula maculata*.—Lower sides of pronotum and lower half of propodeum finely striate. Male: flagellum of antennæ with strong welts (tyloides) on the under side; seventh sternite deeply, semicircularly emarginate, the notch with sharp lateral edges; branches of penis incompletely fused, the basal shaft very broad and expanded beyond the middle, the two apical branches flat and broad, tong-shaped; upper inner edge of stipes forming a broadly rounded angle; volsella of valva interna short and broad, densely hairy, not reaching the tip of the squama of the valva externa. This subgroup comprises *V. maculata* (Linnaeus) and *V. media* (Retzius), which are hardly more than color forms (or races) of one species.

The general distribution of these subgroups shows some points of interest. The subgroup of *V. sylvestris* is exclusively Palearctic. The other subgroups are Holarctic; but while certain species are restricted either to the Old World (*V. germanica*, *V. lewisii*, *V. media*) or to the New World (*V. maculifrons*, *V. pensylvanica*, *V. arenaria*, *V. maculata*, *V. squamosa*, and *V. sulphurea*), others are found in both the eastern and the western hemispheres (*V. vulgaris*, *V. rufa*, *V. austriaca*, *V. norvegica* and *V. adulterina*). Some of these Holarctic species show no appreciable variation, even in color, over their immense area (*V. vulgaris* and *V. austriaca*); more often though (*V. rufa*, *V. norvegica* and *V. adulterina*), they have produced a number of color forms, some of which may be restricted either to the Neartic or to the Palearctic portion of their territory. It should, moreover, be noted that the characters separating some of

<sup>8</sup> To judge from the descriptions, *V. omissa* (Bischoff, 1931) is identical with *Vespula norvegica saxonica* morpho *ingrica* Birula (October, 1930), in which case the species will have to be called *Vespula ingrica* (Birula).

the strictly Nearctic and strictly Palearctic species of the same subgroup are very slight, so that these species in each case are clearly offshoots from some common ancestral stock.

*V. koreensis* and *V. structor* have been placed in their respective subgroups on the basis of queens and workers only. *Vespula orbata* (R. du Buysson) and *V. lama* (R. du Buysson) are as yet unknown to me.

#### Subgenus *Vespula*, proper

Oculo-malar space short, at most half the length of the penultimate antennal segment in the male; in female and worker almost absent, the eye practically touching the mandibular condyle. Tibiae as a rule without erect, long hairs on the upper face (except in *V. austriaca*), a few erect hairs being found near the base only. Vertical carina of the sides of the pronotum obsolete or faintly marked only in the lower portion. Third cubital cell about as long on the radius as on the cubitus (rarely a little longer). Male: flagellum of antennae without distinct raised welts (tyloides) on the under side; branches of penis completely fused throughout into a single piece.

As a rule, the species of this group nest underground or in cavities inside fallen logs. Exceptionally the nest is placed close to the ground in bushes, in the shelter of a rock or among roots. It is never truly aerial.

#### 1. *Vespula vulgaris* (Linnaeus).

*Vespa vulgaris* Linnaeus, 1758, Syst. Nat., 10th Ed., I, p. 572 (Europe; the holotype, a queen, is at the Linnean Society in London).

*Vespa communis* H. de Saussure, 1857, Stettin. Ent. Zeitg., XVIII, p. 117 (♀; North America).

*Vespa alascensis* Packard, 1870, Trans. Chicago Ac. Sci., II, p. 27, Pl. II, fig. 10 (♀; Lower Yukon, Alaska).

*Vespa westwoodii* Shipp, 1893, Psyche, VI, p. 450 (Boreal America).

Provisionally I regard *V. vulgaris* as specifically distinct from *V. maculifrons* (R. du Buysson), the two species differing structurally in the male only by the shape of the disk and apex of the seventh abdominal tergite, as indicated in the key. This view is based upon the following arguments: (1) all European males with the penis of *V. vulgaris* have the same type of seventh tergite, viz., the *vulgaris* type; (2) in North America, where both the *vulgaris*

and *maculifrons* types of seventh tergite occur, no transitions have been observed between the two; (3) so far as studied, all males taken or bred from one nest show the same type of seventh tergite; (4) the two types are somewhat geographically segregated: only the *vulgaris* type is known from the Pacific Coast and the Rocky Mountains; in eastern North America, where both types occur, *vulgaris* is more northern and *maculifrons* more southern, although their areas partly overlap. I have been unable to find a consistent and wholly reliable difference in the male genitalia between *V. vulgaris* (Fig. 2A) and *V. maculifrons*.

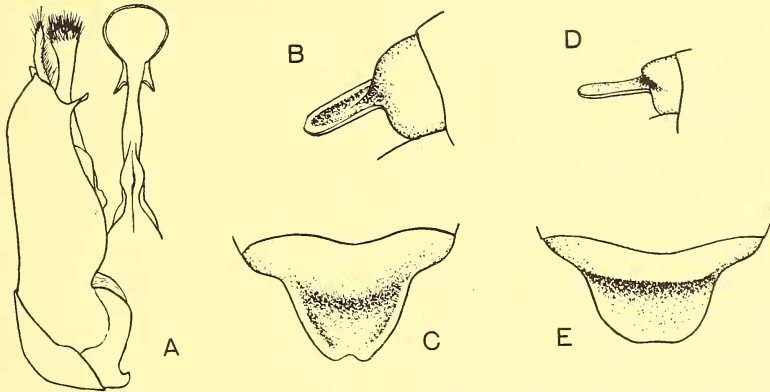


Fig. 2. A-C, *Vespa vulgaris* (Linnaeus): A, male external genitalia in dorsal view; B, seventh tergite of male in profile; C, the same in dorsal view. D-E, *Vespa maculifrons* (R. du Buysson): D, seventh tergite of male in profile; E, the same in dorsal view.

Queens and workers of *V. vulgaris* are, on the whole, more melanistic than those of *V. maculifrons*, but there are many transitions in coloration, due either to overlapping fluctuating variations or to hybridism. The occurrence of either *vulgaris* or *maculifrons*, or of both, in a given locality cannot be positively asserted without the examination of males.

*V. vulgaris* is widely distributed over the Palearctic Region. In North America it extends across the continent, approximately between 35° and 60° Lat. N. In the eastern half of the continent it is of more northern distribution and one of the more common yellow-jackets in the Canadian Zone (between 45° and 50° Lat. N.); but it enters also the Transition Zone, where it is sometimes found together with *V. maculifrons*. In the mid-Atlantic States it is restricted to the mountains. West of the Mississippi it is found

throughout the Rocky Mountain region from New Mexico to Alberta, and on the Pacific Coast it appears to be fairly common from southern Alaska and the Yukon Territory to central California. *V. vulgaris* has also been introduced into New Zealand (G. M. Thompson, 1923, p. 227).

I have seen males with the *vulgaris* type of seventh tergite from California, Alberta, North Dakota, New York, Connecticut, Massachusetts, Canada (Sherbrook), and the Hudson Bay Territory. Queens and workers, most probably belonging to *V. vulgaris*, I have examined from Alaska, Yukon Territory, British Columbia, Vancouver Island, Alberta, Washington State, Oregon, California, Idaho, Utah, Colorado, New Mexico, North Dakota, Iowa, Minnesota, Illinois, Michigan, Nova Scotia, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Virginia, and North Carolina.

In Europe, *V. vulgaris* builds almost always underground, the nest consisting of several tiers of paper cells as a rule completely wrapped in a brittle envelope of paper. In the rare cases when a nest is found above ground, it is placed in a well-sheltered spot. Undoubtedly some of the accounts of supposed aerial nests of *V. vulgaris* were due to misidentifications. This is notably the case for that given by Degeer (1771, Mém. pour Servir à l'Hist. Insectes, II, 2, p. 772), which refers to *V. norwegica* var. *saxonica* (Fabricius). In North America, J. Wyman's (1861) observations on the nest of an undetermined *Vespa*, found in the slope of a bank at Cambridge, Mass., were possibly based upon *V. vulgaris*. I have found a nest of this species in the Adirondaeks, N. Y., placed inside the decaying stump of a tree, nearly in the center. A very brittle cover of paper enveloped the whole nest, the entrance to the cavity being on the side of the stump. Mr. R. P. Dow, in 1929, dug up two underground nests, which, to judge from the specimens I examined, were built by *V. vulgaris*. One of these, found at Cold Spring Harbor, N. Y., on September 3, was resting on the sloping surface of a root, to which it was partly fastened; it consisted of three large combs and a smaller one, all inside an envelope of paper. Males were later bred from this nest. Some of the cells contained pupae of the ichneumonid, *Sphécophaga burra* (Cresson); before pupating, the larva of this parasite closes the cell, some distance below the top, with a brownish, silken partition, showing a slightly depressed, translucent circle in the center. Mr. Dow's other nest, from Huntington, Mass., August 18 and 19, showed no paper en-



velope around the four combs, which were attached among the roots of a black birch. It contained a queen and 183 workers. Mr. S. W. Bromley has recently (Sept., 1931) sent me queens, workers and males taken from an underground nest at Stamford, Connecticut.

2. *Vespula maculifrons* (R. du Buysson).

*Vespa maculifrons* "H." R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, 4, (1904), p. 608 (as a synonym of *Vespa communis* H. de Saussure, the name being found on the label of a specimen from Wilmington, Delaware, at the British Museum).

*Vespula maculifrons* Rohwer, 1926, Proc. Ent. Soc. Washington, XXVIII, p. 94.

*Vespa communis* var. *flavida* Sladen, 1918, Ottawa Naturalist, XXXII, p. 71 (♀; Eastern Canada, of "more southern range"; without more definite locality).

This is the wasp which in the eastern United States and Canada has often been called "*Vespa germanica*." In my opinion the true *Vespula germanica* (Fabricius), of the Palearctic Region, has never yet been found in North America. All the so-called *V. germanica* from eastern North America, which I have seen in collections, differ from that species in the female and worker having the apical margin of the mandible shaped as in *V. vulgaris*; while in the male the shape of the seventh tergite and of the genitalia is very different. In true *V. germanica* the seventh tergite is evenly depressed beyond the gradually sloping convex base and usually has a distinct emargination at the apex, as in *V. vulgaris*; the genitalia have the shaft of the penis with narrow, wing-like expansions ventrally, close to the apical spoon, which is heart-shaped, with emarginate apex; the upper inner edge of the stipes of the valva externa forms a blunt lobe, which is much longer than wide (Fig. 3B). I have, however, not been able to find any reliable difference in color pattern between *V. germanica* and *V. maculifrons*.<sup>9</sup>

<sup>9</sup> Incidentally it may be noted that *V. vulgaris* and *V. germanica* are, in my opinion, two perfectly valid species, and not merely color variations of one specific type, as certain authors have claimed in Europe. In the males, each of these species is characterized by the peculiar shape of the genitalia (compare Fig. 2A and Fig. 3B), no transitions between these two types having ever been reported. In addition, the females and workers show a constant difference in the shape of the apical margin of the mandible, as recently pointed out by Bischoff (1931, Mitt. D. Ent. Ges., II, p. 7).

*V. maculifrons* is strictly North American and is commonly found in the eastern half of the continent throughout the Upper and Lower Austral and Transition Zones, between 28° and 48° Lat. N. I have seen males with the *maculifrons* type of seventh tergite from Maine, Massachusetts, Connecticut, New York, New Jersey, Maryland, Washington, D. C., Virginia, Texas, Nebraska (South Bend, Cass Co.), Kansas (Manhattan, all phases from two nests dug out by Mr. A. W. Lindquist), Michigan, and North Dakota; also queens and workers almost certainly of the same species from Quebec, Ontario, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Washington, D. C., Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida (Enterprise; Lakeland), Alabama, Arkansas, Texas, Missouri, Tennessee, Kansas (Douglas Co.), Nebraska (Omaha; La Platte; Fort Calhoun), North Dakota (Kelly; Grand Forks; Arvilla), Minnesota, Iowa, Illinois, Michigan, Indiana, and Ohio. There is no evidence of *maculifrons* having ever been taken west of the 100th Meridian.

Although the name "*maculifrons*" should be credited to R. du Buysson, since he was the first to validate it by citing it in connection with a description or published name, it was actually proposed nearly a century ago by Thomas Say. It was first used in print by Thaddeus Harris in 1833 (in Hitchcock, Report on the Geology, Mineralogy, Botany of Massachusetts, p. 589), but without a description or a reference to a described species. Here the name is followed by "S," an abbreviation for "Say, MS." Moreover, Harris' collection, now preserved at the Boston Society of Natural History, contains two workers, without locality, bearing Say's manuscript label, which agree with Rohwer's and my interpretation of *maculifrons*.

Most, if not all, the accounts of the habits credited by North American entomologists to *V. germanica* really refer to *V. maculifrons*. This is notably the case for those published by W. Couper (1870), C. L. Marlatt (1891), W. H. Ashmead (1894), P. and N. Rau (1918), and P. Rau (1930 and 1931). Moreover, the habits of *maculifrons* are essentially the same as those of *germanica* and *vulgaris*. The nest is usually placed underground, sometimes inside decayed stumps or hollow logs, or even in more unusual places. In mid-summer it comprises four to eight horizontal combs of cells, opening downward, and some 400 to 700 workers in addition to the old queen. P. Rau (1930) describes a nest consisting of only one

very large comb. Late in August the first males appear and these are followed a few weeks later by the virgin females. Mating takes place outside the nest and the impregnated females soon go into hiding for the winter. During hibernation they keep the plaited wings beneath the sides of the body, tucked away between the hind legs and the abdomen. The old colony dies out completely in the fall and the nests are usually deserted, although H. Skinner has recorded a nest collected near Philadelphia in the dead of winter and containing live wasps (1905, Ent. News, XVI, p. 25). In any case the young females never return to the old nests in spring, but each of them seeks out a location where she starts a new nest. These young queens appear rather late in the spring (about May or early June in Massachusetts).

According to Janet and other European observers, the nests of *V. vulgaris* and *V. germanica* may be readily recognized by the different appearance and texture of the enclosing cover. In *V. vulgaris* the envelope is described as very brittle, more or less dirty yellowish, and built of numerous, irregularly imbricated scales, so that it appears fluted or scalloped. *V. germanica* is said to build a more consistent cover of fibrous paper, grayish and forming a number of large, concentric sheets. It would be interesting to investigate whether somewhat similar differences might not characterize the nests of *V. vulgaris*, *V. maculifrons* and *V. pensylvanica* in North America.

### 3. *Vespula pensylvanica* (H. de Saussure).

*Vespa pensylvanica* H. de Saussure, 1857, Stettin. Ent. Zeitg., XVIII, p. 117 (♀; North America, Canada and the mountains of Mexico). R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, 4, (1904), p. 615 (♀ ♂).

*Vespa occidentalis* Cresson, 1874, Trans. Amer. Ent. Soc., V, p. 100 (♀ ♂, erroneously described as ♀ ♂; Nevada and New Mexico). Not *Vespa occidentalis* Olivier, 1791.

It appears that de Saussure originally based his *V. pensylvanica* upon a mixture of eastern (Canadian) specimens of what is now called *Vespula maculifrons* (R. du Buysson) and of western (Mexican) specimens of Cresson's *Vespa occidentalis*, although the statement "antennarum scapo antice flavo" is true of the western species only. R. du Buysson who examined one of de Saussure's cotypes from Mexico, at the Paris Museum, recognized that this

wasp was identical with *V. occidentalis* Cresson. Being the first reviser, he had the right to restrict the name *pensylvanica* to the western species, and there seems to be no way of avoiding the name, even though the species does not occur in Pennsylvania. Moreover, if *V. pensylvanica* were rejected as inappropriate or misleading, a new vocable would have to be introduced, since Cresson's name is invalidated by the earlier *Vespa occidentalis* Olivier (now placed in *Polybia*).

*V. pensylvanica* is peculiar to western North America, where it replaces *V. maculifrons*. Here it occurs between 18° and 52° Lat. N., mainly, it would seem, in the Transition Zone and as high up as 8,000 ft. In the southern part of its range it is rare and restricted to the mountains. Males with the genitalia and seventh tergite of

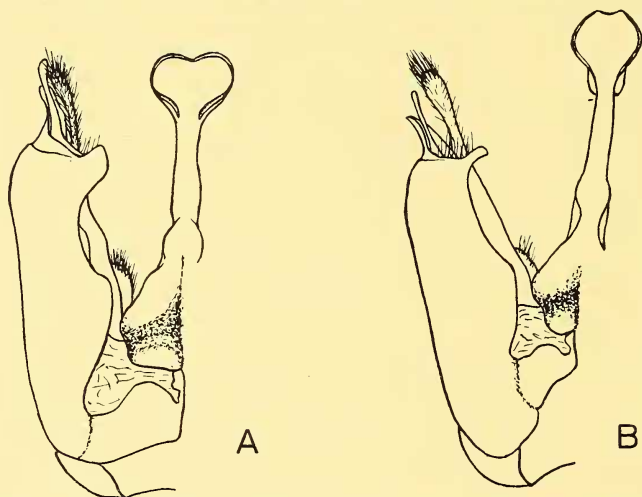


Fig. 3. A, male external genitalia of *Vespa pensylvanica* (H. de Saussure). B, the same of *Vespa germanica* (Fabricius). Both in dorsal view.

*pensylvanica* I have seen from Washington State, Oregon, California, Utah, Colorado, South Dakota, Arizona, and Mexico. I also refer to this species queens and workers from British Columbia (Terrace; Vernon; Nanaimo Biological Station; Selkirk Mountains; Kaslo), Vancouver Island, Washington State, Oregon, California, Idaho, Nevada, Utah, Wyoming, Colorado, South Dakota (Black Hills), Nebraska (Squaw Canyon, Sioux Co.), Arizona, New Mexico and Mexico City. There are reliable published records from Alberta and Montana. Probably the species occurs in the extreme western part of Kansas, but E. S. Tucker's record of *V. occidentalis*

from Lawrence, Kans. (1909, Trans. Kansas Ac. Sci., XXII, p. 285) I regard as based upon misidentified *V. maculifrons*. Males with the characters of *V. pensylvanica* have never yet been found east of the 100th Meridian. *V. pensylvanica* has been introduced by man into Kauai, Hawaiian Islands, where it was first recorded in 1919 and appears now to be common locally (O. H. Swezey, 1921, and F. X. Williams, 1931). Dr. Williams has sent me Hawaiian specimens, including males.

Very few observations have as yet been made regarding the habits of *V. pensylvanica*. According to G. W. Taylor's (1898) account, they are similar to those of *V. maculifrons*, the nest being placed underground. Taylor captured at the entrance of the nests, in British Columbia, 23 males and 4 females of an interesting parasitic wasp, *Trigonalys canadensis* Harrington.

#### 4. *Vespula rufa* (Linnaeus).

*Vespa rufa* Linnaeus, 1758, Syst. Nat., 10th Ed., I, p. 572  
(Europe; based on a worker).

This species occurs throughout the Palearctic and Nearctic Regions, in the following color forms:

(1) Typical *V. rufa*, with dull yellow markings and with rufous spots on the first or first and second abdominal tergites, at least in the worker; the rufous is rarely absent or diffuse in the male, but often lacking in the queen. Linnaeus' holotype, at the Linnean Society of London, is a worker in which, as Mr. Robert B. Benson writes me, "the first and second abdominal segments are marked with russet." This form occurs over most of Europe and western Asia, as far east as Long. 130°; northward it reaches 70° Lat. N., southward it extends into northern Spain, Italy, Crimea, Transcaucasia and Pamir. I have never seen it from North America and I regard all American published records of typical *V. rufa* as based upon misidentifications.

(2) *V. rufa* var. *schrenckii* (Radoszkowsky, 1861), of which *Vespa sibirica* Edm. André (1884) is a synonym, differs from the typical form in the pale markings being dirty-white or ivory-white, while (even in the worker) the russet spots are more often reduced or absent; they are never present in the queen. This form is found in northeastern Asia, between 110° Long. E. and the Pacific; it extends from the shores of the Arctic Ocean to northeastern Mongolia and I have also seen it from Japan.

(3) *V. rufa* var. *intermedia* (R. du Buysson). North America.

(4) *V. rufa* var. *atropilosa* (Sladen). Northwestern America.



- (5) *V. rufa* var. *vidua* (H. de Saussure). Northeastern America.  
 (6) *V. rufa* var. *acadica* (Sladen). Northeastern America.  
 (7) *V. rufa* var. *sladeni* J. Bequaert. Northwestern America.  
 (8) *V. rufa* var. *consobrina* (H. de Saussure). North America.

My interpretation of the last-named six forms as North American representatives of *V. rufa* is based upon the failure to find structural characters to separate them from one another and from European specimens of typical *rufa*. In particular, the male genitalia of all these forms seem to me identical in every important detail.

4a. *Vespula rufa* var. *intermedia* (R. du Buysson).

*Vespa rufa* var. *intermedia* R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, 4, (1904), p. 591 (♀ ♂; region of Lake Hanka in Manchuria and Hudson's Bay in North America).

This form is so close to the var. *schrenckii* of northeastern Asia, that I greatly doubt the advisability of keeping it separate. It differs from *schrenckii* only in the presence of more or less extensive russet markings on the first and second tergites of the queen, these markings being usually also found in the worker and male. From typical *rufa* it differs in the pale markings being ivory-white instead of yellow. L. Provancher (1882 and 1883) and T. W. Fyles (1903) based their descriptions of *V. rufa* upon specimens of the var. *intermedia*.

I regard the var. *intermedia* as peculiar to the Hudsonian Zone of boreal North America, where it seems to extend across the Continent. It is very rare in collections. I have seen it from Alaska (1 ♀ without more definite locality; 1 ♀ from the Lower Yukon; 1 ♀ from 850 miles up the Anvik River), North West Territory (1 ♂ from Oklavik on the Mackenzie River), Canada (2 ♀ without more definite locality), and Labrador (1 ♀ from Rama). There are reliable published records from eastern Canada (Chicoutimi and the Island of Orleans) and from Manitoba (Mile 137 of the Hudson's Bay Railway). I propose to select Hudson's Bay as the type locality, since I believe that du Buysson's specimen from Lake Hanka, in Manchuria, actually belonged to the var. *schrenckii*. Unfortunately R. du Buysson does not say whether the North American specimen (which is at the British Museum) was the queen or the male.

No account of the nesting habits is available.

4b. *Vespula rufa* var. *atropilosa* (Sladen).

*Vespa atropilosa* Sladen, 1918, Ottawa Naturalist, XXXII, p. 72 (♀ ♂; Lethbridge, Alberta; Vernon, Keremeos and Okanagan Landing, British Columbia).

This is an extreme xanthic form of *V. rufa*, widely distributed throughout western North America, where it covers much the same area as *V. pensylvanica*. Until Sladen's work, it was generally confused with that species, although structurally it is very different. There are, moreover, usually a number of color peculiarities by means of which *pensylvanica* and *atropilosa* may be told apart: (a) the yellow spots of the propodeum are usually present in *pensylvanica*, as a rule absent in *atropilosa*; (b) the black spots of the second tergite are regular rounded extensions of the black base in *pensylvanica*, whereas in *atropilosa* they are oblique and tend to fuse with the median triangular notch; (c) the black diamond of the first tergite is elongate and rather narrow in *pensylvanica*, wide and transverse in *atropilosa*; (d) the mesonotum often has yellow spots before the scutellum in *pensylvanica*, hardly ever in *atropilosa*; (e) the yellow ocular sinuses are usually connected with the outer orbits along the sides of the vertex in *pensylvanica*, as a rule broadly separated in *atropilosa*. All these differences in color, however, admit of exceptions.

I have seen the var. *atropilosa* from British Columbia (Kaslo; Fort McLeod; Vernon), Vancouver Island, Alberta (Medicine Lake), Washington State, Oregon, California, Idaho, Nevada, Montana, Wyoming, Utah, Colorado, Arizona, and Lower California (Tia Juana). Most likely it occurs also in New Mexico. The United States National Museum has one worker labelled "Texas, Belfrage," which may have been obtained in the western part of that state. There is, however, no reliable record of its occurrence east of the 100th Meridian.

Lewis' description of *Vespa infernalis* (1897) was almost certainly based upon specimens of the var. *atropilosa*, which is sometimes found in American collections as "*infernalis*." H. de Saussure's original description of *V. infernalis* (1853), however, was drawn most likely from a female of *V. austriaca* (Panzer).

No observations have as yet been published regarding the nesting habits of this wasp. Mr. C. D. Duncan has sent me some specimens from a nest dug up in Utah, so that we may suppose that it builds underground or partly above the soil, like typical *V. rufa* and the var. *vidua*.

4c. *Vespula rufa* var. *vidua* (H. de Saussure).

*Vespa vidua* H. de Saussure, 1853, Et. Fam. Vesp., II, p. 136 (♂; Carolina).

The well-known *vidua* is readily recognized by the usually bright yellow markings, which are very extensive on the third and succeeding abdominal segments, while on the first and second they are reduced to a narrow apical margin; in addition, the edge of the first tergite bears two narrow transverse streaks (very rarely absent).

The var. *vidua* occurs throughout southeastern Canada and the eastern United States, where it is most common in the Upper

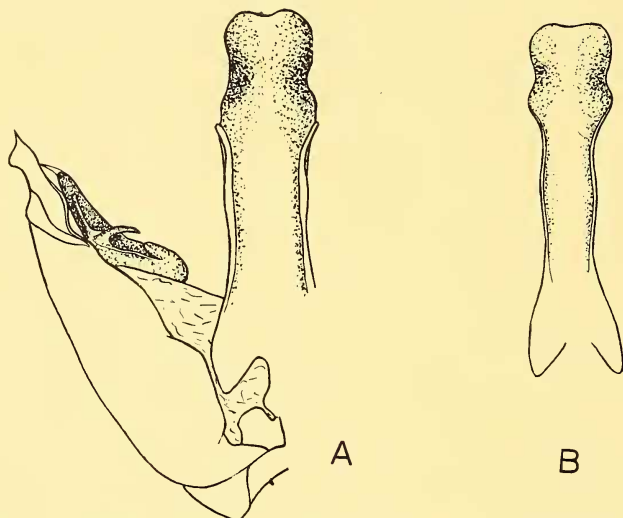


Fig. 4. A, male genitalia of *Vespula rufa* var. *vidua* (H. de Saussure); only the penis and the several parts of the valva interna dotted. B, penis of *Vespula austriaca* (Panzer). Both in dorsal view.

Austral Zone; occasionally it is found in the Transition Zone also. I have seen it from Ontario, Nova Scotia, Maine, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, Washington, D. C., Virginia, North Carolina, Georgia (Macon), Texas (one specimen without more definite locality, collected by Belfrage; this record needs confirmation), Indiana, Michigan, Wisconsin, Illinois, Minnesota, and North Dakota (Traill Co.).

Although this wasp is by no means rare, no account of its habits appears to have been written thus far. It nests underground.

S. W. Bromley (1923) lists it among the prey of the robber fly, *Proctacanthus rufus* Williston.

4d. *Vespula rufa* var. *acadica* (Sladen).

*Vespula acadica* Sladen, 1918, Ottawa Naturalist, XXXII, p. 72 (♀ ♂ ♂; in part: specimens from Nova Scotia; Painsec, New Brunswick; and Ottawa).

*Vespula rufa* var. *americana* R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, 4, (1904), pp. 499, 500, and 592 (♂; Lewis near Quebec, Canada). Not *Vespula americana* Fabricius, 1775, nor *Vespula maculata americana* Christ, 1791.

Although only an examination of the types could positively settle the identity of du Buysson's var. *americana*, I believe that it was based upon a male color variant of Sladen's *V. acadica*, which I regard as a variety of *V. rufa*. A series of nine males, collected by Mr. G. B. Fairehild in Cape Breton Island, September 5, 1928, is extremely instructive in this respect. Six agree with du Buysson's description of var. *americana* in lacking free yellow spots on the second tergite, while they differ from males of var. *vidua* in having all the apical yellow fasciae of the tergites of about equal width; in one of them the free yellow streaks of the first tergite are barely indicated. One specimen has traces of free yellow dots on the second tergite, while in another these dots are quite distinct. In the ninth specimen there are two large spots on the disk of the second tergite, which, moreover, are connected both on the inner and outer angles with the apical fascia (thus enclosing a black spot); this specimen also has the yellow areas of the first tergite decidedly tinged with reddish. This series, taken the same day in the same locality, shows beautifully the relationship of *acadica* to typical *V. rufa* as well as to the var. *vidua*.

Sladen's *V. acadica* covered all specimens, of eastern as well as of western North America, intermediate in coloration between the var. *atropilosa* and the var. *vidua*. These specimens can, however, not possibly be accounted for by crossing of those two forms, which nowhere are known to occur together and whose ranges do not overlap. In my opinion, the eastern specimens of Sladen's *acadica* are extreme xanthic variants of the var. *vidua*, often with more or less extensive yellow spots in the black area of the second tergite. The western wasps which Sladen included in his "*acadica*," on the other hand, are, I believe, a melanistic variation of the var. *atropilosa*, with much reduced yellow markings. In the present paper,

I describe this western form as var. *sladeni*. Through convergence, these eastern and western variants have come to look alike, so much so indeed that without referring to the locality labels, they often cannot be told apart. Nevertheless, if my interpretation be correct, they have a totally different ancestry, a fact which should, I believe, be duly recognized in the nomenclature. I shall therefore restrict the name *acadica* Sladen to the eastern form, Sladen's specimens from Nova Scotia, New Brunswick (Painsec), and Ottawa being the cotypes. His specimens from Kalso and Victoria, British Columbia, I refer to the new variety *sladeni*.

I have seen specimens of the var. *acadica* (as here restricted) from Canada (without definite locality), Nova Scotia (Portau-pique; MacNabs Island; Halifax; Dublin Shore, Lunenburg Co.; Baddeck, Cape Breton Island), Quebec (Ironside), Hudson's Bay Territory, Maine (Ocean Point, 1 ♀; Wadloboro; N. E. Harbor, Mt. Desert), New Hampshire (Passaconaway; Mt. Washington), Minnesota (Two Harbors), and South Dakota (Custer). I suspect that the var. *acadica* will be found sporadically throughout the range of the var. *vidua* and in the nests of that form.

4e. *Vespula rufa* var. *sladeni*, new variety.

*Queen* (holotype).—Black, without traces of rufous, with bright yellow markings (nearest Ridgway's light cadmium) as follows: clypeus (except for the margins and an irregular, median, black streak, extending from the upper margin to below the middle, where it is connected with two small spots); a large lozenge-shaped spot between the antennae; a spot in the inner edge of the ocular sinus; a streak in the upper part of the outer orbit (close to the eye); most of the mandibles; under side of antennal scape; broad hind margins of pronotum; two large, transverse spots on scutellum; a triangular spot in the upper mesepisternum (beneath the base of the wings); most of the tegulae; moderately wide apical margins of the abdominal segments; two free spots on each of tergites 1 to 5; broad apices of femora; and most of the tibiae and tarsi. The yellow fascia is fairly uniform on tergite 1, which bears two transverse streaks on the edge; the fasciae are gradually wider on the sides of tergites 2 to 5; those of tergites 3 to 5 each have two semi-circular, anterior notches, corresponding to the pair of free, yellow spots; black area of tergite 2 also with two free, yellow spots; on the sternites each fascia has three very wide emarginations; tergite 6 with the side margins broadly yellow, the corresponding sternite black.



Length (h. + th. + t. 1 + 2) : 11 mm. ; of wing : 12.5 mm.

*Worker* (allotype).—In most respects like the queen, except for the following: the black mark of the clypeus more or less broken up into three spots; lower part of outer orbit also with a yellow streak; two transverse yellow spots on postscutellum; free spots of second tergite much smaller; tergites 3 to 5 without free spots; femora more extensively yellow.

Length (h. + th. + t. 1 + 2) : 9 mm. ; of wing : 8.5 mm.

*Male* (allotype).—Very similar to the worker allotype, but the yellow more extensive on the head (clypeus with only a minute central black dot; ocular sinuses completely filled with yellow; outer orbits yellow the whole length of the eyes); yellow spots of postscutellum very small; second or second and third tergites with small, free, yellow spots; seventh tergite with the sides broadly yellow, separated to the tip by a median black band. Genitalia as in typical *V. rufa*.

Length (h. + th. + t. 1 + 2) : 11 mm. ; of wing : 12.5 mm.

In coloration these specimens can readily be matched with queens, workers and males of the eastern *V. rufa* var. *acadica* (Sladen). Some of the western specimens which I refer to var. *sladeni* show, however, a marked departure from the descriptions given above, in that, at least in the worker and male, the free spots of the second tergite may be either very small or entirely lacking. Specimens without free spots can, of course, not be distinguished from *V. rufa* var. *vidua* (H. de Saussure), except by their western origin, the true var. *vidua* having never been found west of the 100th Meridian. In one worker from Sitka, Alaska, the free spots of the first tergite have also disappeared. On the other hand, I have seen workers of *V. rufa* var. *atropilosa* (Sladen) in which the anterior spots of the first and second tergites were barely connected with the apical yellow areas. Such specimens connect the var. *atropilosa* with the form here described as var. *sladeni* and indicate the genetic relationships between the two.

My reasons for regarding var. *sladeni* as an extreme, melanistic variation of var. *atropilosa* are as follows: (1) one may, with sufficient material arrange a regular sequence of specimens showing all passages from the one to the other; (2) there is no evidence that the var. *vidua* occurs west of the 100th Meridian; at any rate, no true queens of *vidua* have ever been found in the western area; and (3) specimens of the form here described as *sladeni*, although rare, occur sporadically throughout the area occupied by *atropilosa*, particularly in the northern part of its range.

The description of the var. *sladeni* is based upon specimens from the following localities: ALASKA: Sitka, one worker, paratype.—VANCOUVER ISLAND: one worker, paratype (Am. Mus. Nat. Hist.)—BRITISH COLUMBIA: Skagit Valley, one worker, paratype.—WASHINGTON STATE: one queen, holotype.—OREGON: Three Sisters, two workers, paratypes; Oregon Mt., Josephine Co., one worker, allotype; Mt. Hood, one worker, paratype (U. S. Nat. Mus.), and one queen, paratype (Oregon St. Agr. C.); Crater Lake Park, five workers, paratypes (Oregon St. Agr. C.); Newport, one worker, paratype (Oregon St. Agr. C.); Lake of the Woods, Klamath Co., one worker, paratype (Oregon St. Agr. C.); Mt. McLaughlin, Klamath Co., one worker, paratype (Oregon St. Agr. C.).—CALIFORNIA: Santa Cruz Mountains, one queen, paratype; Laws, one male, allotype.—WYOMING: Stewart Ranger Station, one worker, paratype (Am. Mus. Nat. Hist.).—UTAH: Ogden, one male, paratype; Utah Lake, East Side, one male, paratype; Uintah Mts., one worker, paratype.—COLORADO: Boulder, one queen, paratype. The holotype and allotypes are at the Mus. of Comp. Zoöl., Cambridge, Mass. Before I made the distinction between the eastern var. *acadica* and the western var. *sladeni*, I had named in various collections specimens from Alaska, Oregon, California, and Idaho, calling them "*acadica*." Although these specimens are not now available for study, I feel certain that they all belonged to the var. *sladeni*.

If my interpretation of the var. *sladeni* is correct, this form should be found in the nests of *V. rufa* var. *atropilosa*.

4f. *Vespula rufa* var. *consobrina* (H. de Saussure).

*Vespa consobrina* H. de Saussure, 1853, Et. Fam. Vesp., II, p. 141 (♀; Newfoundland).

*Vespa arenaria* H. de Saussure, 1853, Et. Fam. Vesp., II, p. 134 (♀; North America). Not *Vespa arenaria* Fabricius, 1775.

*Vespa scelestus* McFarland, 1888, Trans. Amer. Ent. Soc., XV, p. 298 (♀ ♀ ♂; Pennsylvania; Virginia; New Hampshire; Colorado; Montana; Maine; Washington State; Massachusetts). Cresson, 1928, Mem. Amer. Ent. Soc., No. 5, p. 57 (♀ from Montana at Ac. N. Sci. Phila., selected as type.)

*Vespa sulcata* L. O. Howard, 1901, The Insect Book, Pl. VI, fig. 18 (♀; without locality or description; probably misspelling of *scelestus*).

Structurally this well-known wasp is not separable from the several forms of *V. rufa*. For a long time I believed to have found

slight differences in the male genitalia, *viz.*, in the shape of the valva interna; but repeated observation has convinced me that these supposed differences are only apparent and not reliable.

The var. *consobrina* extends across the American Continent, being mainly an insect of the Canadian Zone. In the Transition Zone it is still fairly common, but it is much rarer in the Upper Austral. Northward it reaches about to 52° Lat. N., and southward into the mountains of North Carolina and the Rockies of Colorado. I have seen it from Hudson Bay Territory, Ontario, Quebec, Nova Scotia, Anticosti, Newfoundland, Maine, New Hampshire, Massachusetts, Vermont, Connecticut, New York, New Jersey, Pennsylvania, Virginia, North Carolina (Mt. Mitchell; Blowing Rock; Sunburst, Haywood Co.; Swannanoa; Black Mountains), Illinois, Michigan, Wisconsin, Minnesota, North Dakota (Grand Forks; Fargo), South Dakota (without more definite locality), Montana, Wyoming, Colorado, Utah, California (Redlands), Oregon, Washington State, British Columbia (Vernon; Terrace; Revelstoke and Beaver Mouth, Selkirk Mts.; Kaslo), Vancouver Island, Alberta (Atabasca Delta; Calgary; Bilby; Banff), and Saskatchewan. I have seen an old specimen labelled "New Orleans"; but this locality, as well as R. du Buysson's record from "Texas," appear very doubtful. The hibernating queen which Blatchley recorded from Indiana as *V. arenaria*, was probably the var. *consobrina* (1896, Psyche, VII, p. 458).

The nest of the var. *consobrina* is generally placed underground among roots or in the shelter of a rock; sometimes also on or close to the ground in brushwood. R. P. Dow (1930, Bull. Boston Soc. Nat. Hist., No. 56, p. 12) has published a photograph of a nest, dug up at Huntington, Mass., August 18 to 20. It was placed in humus soil, beneath the roots of mountain laurel, but not attached by a definite petiole. It consisted of three combs, inside a paper envelope of at least three layers. One nest which I found at Chittenden, Vermont, in August, 1916, was small and placed at a depth of about four or five inches in what appeared to be an old mouse nest.

##### 5. *Vespula austriaca* (Panzer).

*Vespula austriaca* Panzer, 1799, Faun. Ins. German., VI, pt. 63, Pl. II (♂; Vienna, Austria).

*Vespula borealis* F. Smith, 1843, The Zoologist, I, p. 170, fig. (♀; Yorkshire, England; and north of Scotland).

Not *Vespula borealis* W. Kirby, 1837, nor of Zetterstedt, 1840.

*Vespa arborea* F. Smith, 1849, The Zoologist, VII, Appendix, p. lx (substitute name for *Vespa borealis* F. Smith, 1843).

*Vespa tripunctata* Packard, 1870, Trans. Chicago Ac. Sci., II, p. 26, Pl. II, fig. 11 (holotype ♀ of Kutleet, Alaska, only). Not *Vespa tripunctata* Fabricius, 1787, nor of Schenck, 1861.

*Vespa infernalis* H. de Saussure, 1853, Et. Fam. Vesp., II, p. 139 (described as ♂, but probably a ♀; Philadelphia).

The main description and the figure of *V. tripunctata* were drawn from a female (now lost) of *V. austriaca*; but the additional specimens discussed by Packard in a footnote (p. 27), belong to other species. These specimens are now at the Museum of Comparative Zoölogy in Cambridge, where I have seen them. The female from Springfield, Oregon, is *V. pennsylvanica* (H. de Saussure); the workers from Fort Bidwell, Siskiyou Co., California, are *V. rufa* var. *atropilosa* (Sladen).

H. de Saussure's *V. infernalis* has been a puzzle for years, owing to the fact that the author placed it among the species with a long oculo-malar space (subgenus *Dolichovespula*). No North American species of that group, however, has the color pattern described for *infernalis*. After studying several thousands of specimens of North American yellow-jackets, I have reached the conclusion that the species was inadvertently placed in the wrong group and that de Saussure described an American female of *V. austriaca*. The peculiar black-and-yellow pattern which he mentions for the second and third tergites is found in that wasp. *V. infernalis* was described from Spinola's collection and the actual specimen might yet be in existence.

In 1916, I have given a complete description of the female of *V. austriaca*, which differs conspicuously from the queen of all forms of *V. rufa* in the long pilosity on the outer side of the tibiae and in the pointed apical angles of the clypeus. In the male the apical edges of the clypeus are also more prominent than in that sex of *V. rufa*. The male genitalia are extremely similar to those of *V. rufa*. After a careful comparative study of several preparations of *austriaca* and of typical (Palearctic) *rufa* and most of its North American varieties, I find that the only dependable difference is in the shape of the penis (compare Fig. 4A and 4B). In *austriaca* the shaft is decidedly more slender, narrower than the apical saddle, with the slightly thickened margins not projecting apicad.

In the several forms of *rufa*, the shaft is wider, slightly broader than the apical saddle and with prominent thickened margins which end apicad in obtuse protuberances. Most of the other differences in the genitalia, pointed out by previous authors, notably by Birula (1930), do not seem to be wholly reliable, an opinion also expressed by H. Bischoff in his recent, excellent study of *V. austriaca* (1931, Sitzungsber. Ges. Naturf. Fr. Berlin, for 1930, p. 332).

*V. austriaca* ranges over the entire Holarctic Realm, but is everywhere one of the rarest wasps. In Europe it is known from the British Isles, Belgium, France, Switzerland, Tyrol, Germany, Scandinavia (northward to 70° Lat. N.), Finland, and the whole of Russia. In Asia it has been recorded throughout Siberia (south of 63° Lat. N.), Kamchatka, Central Asia (Tianschan Mts.), eastern Mongolia (Alaschan Mts.), and China (Shanghai). I have seen the following North American specimens: ALASKA: Savonoski, one female (J. S. Hine).—BRITISH COLUMBIA: Beaver Mouth, Selkirk Mts., two males (J. C. Bradley); Field, one female (D. Brown).—ALBERTA: Banff, one female (G. Salt).—QUEBEC: Montreal, one female (in Coll. T. H. Frison).—MAINE: Bar Harbor, Mt. Desert, one female (C. W. Johnson).—NEW YORK: Staten Island, one female (J. S. Hine); Keesevilla, one female (A. K. Fisher).—NEW JERSEY: Fort Lee, two females (J. Bequaert).—MICHIGAN: two females without more definite locality (M. C. Z.).—COLORADO: Estes Park, one female, 8,000 ft. (R. A. Leussler); one female without more definite locality (Ac. N. Sci. Phila.).—UTAH: Mt. Tuku-nikivatz, La Sal Mts., one female (I. Rasmussen).—OREGON: Crater Lake, one female (C. L. Fox); Mt. Hood, one female (G. P. Engelhardt); Three Sisters, one male (H. A. Scullen).—CALIFORNIA: Yosemite Valley (E. C. Van Dyke). The earliest positive record of the occurrence of this wasp in North America, by R. du Buysson in 1905, was based upon a specimen from the Yukon River, at the Paris Museum. Sladen also saw *V. austriaca* from Quebec (Ottawa; Chelsea), Winnipeg, and British Columbia (Kaslo).

*V. austriaca* has no worker phase. It is a so-called social parasite or inquiline wasp, which builds no nest of its own, but has its brood raised by the workers of other species of *Vespula*. In the Palearctic Region the host-species is *Vespula rufa* (Linnaeus), in the nests of which the females and males of *V. austriaca* have been found repeatedly. In North America, the host is as yet unknown; but since typical *V. rufa* does not exist here, I suspect that it must be one of the more common American forms of *V. rufa* (*vidua*, *atropilosa*, or *consobrina*). In 1916 (Bull. Brooklyn Ent.



Soc., XI, pp. 101–107), I have reviewed what was then known of the habits of this wasp. Birula (1930, Zool. Anzeiger, LXXXVII, p. 132) claims to have found workers of *V. austriaca*; but, as he overlooked the most reliable structural character of the species (*viz.*, the numerous long hairs of the tibiae), I cannot attach much importance to his statement.

6. *Vespula squamosa* (Drury).

*Vespa squamosa* Drury, 1773, Illustr. Nat. Hist., Index to Pt. I published with Pt. II; without name in 1770, *Op. cit.*, I, p. 98, Pl. XLIII, fig. 7 (♀; New York).

*Vespa lineata* Fabricius, 1775, Syst. Entom., p. 365 (America).

*Vespa cuneata* Fabricius, 1804, Syst. Piezat., p. 258 (Carolina).

*Vespa cruciata* Lepeletier, 1836, Hist. Nat. Ins. Hym., I, p. 513 (suggested emendation of *V. cuneata*).

*Vespa carolina* Lepeletier, 1836, Hist. Nat. Ins. Hym., I, p. 513 (♀; Philadelphia). H. de Saussure, 1853, Et. Fam. Vesp., II, p. 142 (♀). Not *Vespa carolina* Linnaeus, 1767.

*Vespa bistriata* McFarland, 1888, Trans. Amer. Ent. Soc., XV, p. 298 (♀; North America). Not *Vespa bistriata* Fabricius, 1804.

*Vespa macfarlandi* Lewis, 1897, Trans. Amer. Ent. Soc., XXIV, pp. 172 and 180 (♀; new name for *V. bistriata* McFarland).

This species has gone thus far under the name “*Vespa carolina* Linnaeus.” Unfortunately Linnaeus’ description was based upon an American species of *Polistes*, as de Saussure found by examining the type at the Linnean Society of London, where it is extant. Mr. Robert B. Benson, who has recently studied it at my request, writes as follows: “*V. carolina*. This specimen is in such appalling condition that I should not like to make any suggestion as to which species of *Polistes* it is. It is unicolorous fuscous with dust. Probably it is one of the dark-winged species and looks superficially like *annularis*.” Moreover, there are several points in Linnaeus’ original description which do not fit the queen of the wasp which in America goes under the name “*carolina*.” Although de Saussure knew that Linnaeus’ *V. carolina* was a *Polistes* (see 1853, Et. Fam. Vesp., II, p. 102, footnote), he nevertheless retained the name “*Vespa carolina*,” but credited it to Drury, who never used it. H. de Saussure’s reference to Drury’s “Illustr. of Ins. Tab. 44, fig. 4” also is erroneous, since that figure represents a *Chlorion*.

The earliest valid name for the wasp here under discussion is *Vespa squamosa* Drury, generally quoted as of 1770, the date of publication of the first volume of Drury's "Illustrations of Natural History," where the wasp is described and figured (Pl. XLIII, fig. 7). The first volume of Drury's work, however, used no binomials, these being introduced in the "Index," which purports

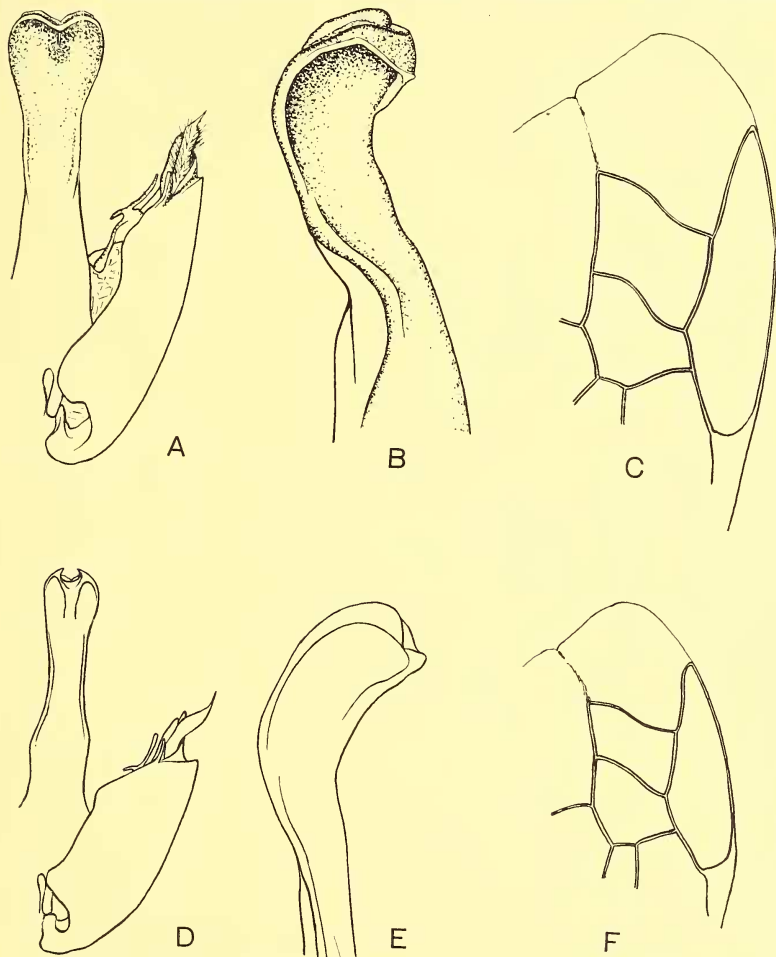


Fig. 5. A-C, *Vespa squamosa* (Drury): A, male external genitalia in dorsal view; B, tip of penis, much enlarged, in profile; C, apical portion of fore wing of queen. D-F, *Vespa sulphurea* (H. de Saussure): D, male external genitalia in dorsal view; E, tip of penis, much enlarged, in profile; F, apical portion of fore wing of queen.

to give the "names of the Insects, according to the System of Linnaeus." Some copies of the first volume lack this Index, others have it pasted in before the plates. The fact that, in this Index, Drury quotes names proposed by Linnaeus in the "Mantissa Plantarum," published in 1771, is intrinsic evidence that the Index was not published together with the first volume, but was issued three years later, with the second volume. Moreover, Westwood's revised edition of Drury's work (1837) invariably credits Drury's binomials of the first volume to "Drury, Append. vol. 2."<sup>10</sup>

H. de Saussure applied the name *Vespa lineata* Fabricius (1775) to a species of *Polistes* from Cuba, described by Lepeletier as *Polistes cubensis*, and subsequent writers have followed the same course. I cannot agree with this conclusion, for I feel certain that Fabricius' original description agrees better with the queen of *Vespa squamosa* Drury, than with any other American wasp known to me. Fabricius' description was based upon a wasp in Drury's collection, with which he became acquainted during a visit to London in 1773 (see Cockerell, 1930, Australian Zoologist, VI, 2, p. 141), and this insect was most probably Drury's specimen of *V. squamosa*.

That *Vespa cuneata* Fabricius was merely the worker of *V. squamosa* was first recorded by Ashmead (1894, Psyche, VII, p. 76). He stated that Mrs. McKewen had taken, from a single nest in Virginia, queens of "*V. carolina*" (= *V. squamosa* Drury) and workers and males of *V. cuneata*. Lepeletier, in 1836, noted that the worker and male of *V. cuneata* are colored much alike.

*Vespula squamosa* is characteristic of the southeastern United States, where it is especially common in the Lower Austral Zone. I have seen it from the following States: New Jersey (rarely seen north of Lakehurst), Pennsylvania (in the eastern part only), Maryland, Washington, D. C., Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas (as far west as Coleman and Kerrville), Oklahoma (Ardmore), Arkansas (Lawrence Co.; Hope; Imboden), Missouri (St. Louis), Indiana, and Illinois. The species must also occur in Tennessee, Kentucky, and Ohio. Sladen has one record from Point Pelée, which is on Lake Erie in the southernmost part of the Province of Ontario. Occasionally a queen is taken near New York City. I

<sup>10</sup> The lepidopterists seem to have generally known that the binomials to Drury's first volume date from 1773. Most other entomologists, however, quote them as of 1770. Dalla Torre, for instance, does so for the Hymenoptera.

have seen one from Pelham Parkway, another from Rockaway Beach (F. M. Schott), and a third taken years ago in Staten Island by Mr. W. T. Davis. Probably these were all stray specimens, accidentally imported by man, as there is no record of a nest having ever been found within the limits of New York State. H. de Saussure knew this wasp from Mexico (1853, Et. Fam. Vesp., II, p. 136; under *V. cuneata*); but the first definite locality from that country was given by R. du Buysson (Tahubaya; probably Tacubaya, a suburb of Mexico City). At the U. S. National Museum I have seen several workers from Mexico City, Tulychualco (State ?), and Puebla (State of Puebla). Prof. T. D. A. Cockerell has sent me a queen labelled: "in bark of dead tree, Puerto Barrios, Guatemala, March 18, 1913 (E. Bethel)"; another queen, with the same data, is at the U. S. National Museum. There is as yet no record of the occurrence of this wasp west of the 100th Meridian.

*Vespula squamosa* is unique, not only in the subfamily Vespinae, but among all social Diploptera, for the extraordinary dimorphism of the sexes. While worker and male are very similar, the queen is so different in size and color-pattern, that for a long time its true identity was not even suspected. Intermediate examples, which in most social Diploptera connect the fertile queens with the sterile workers, are not known for *V. squamosa*. The nest of this wasp is always placed under the ground, as results from the observations of C. L. Marlatt (1891), E. Daecke (1906), C. H. Turner (1908), A. H. Manee (1915), and W. W. Yothers (1925).

#### 7. *Vespula sulphurea* (H. de Saussure).

*Vespa sulphurea* H. de Saussure, 1853, Et. Fam. Vesp., II, p. 137 (♀; California).

This wasp is restricted to the Pacific slope of the Rocky Mountains. I have seen many queens, workers and males from California, where the species seems to occur from the Mexican border to as far north as 40° Lat. N. Mr. T. H. Frison has sent me a queen taken by Oslar in the Huachuca Mts., Arizona. At the Ac. Nat. Sci. Philadelphia there is one worker labelled "Nev.," and since the species is common in California near Lake Tahoe, its occurrence in the extreme western part of Nevada is beyond question. It certainly will be found also in northern Mexico.

*V. sulphurea* is closely allied to *V. squamosa*; but, although worker and queen differ very considerably in size, they are alike in coloration. The male, which appears to be as yet undescribed,

is also similar to the other phases. There is no published account of the habits, but Mr. Carl D. Duncan has informed me that it nests in the ground.

Subgenus *Dolichovespula* Rohwer

Oculo-malar space long, nearly as long as the penultimate antennal segment or longer (in female and worker). Tibiae always with many long, erect hairs over the entire upper surface, especially noticeable on the hind legs. Vertical carina of the sides of the pronotum complete, well-developed in the upper portion also. Third cubital cell much longer on the radius than on the cubitus. Male: flagellum of antennae often with more or less distinct longitudinal welts (tyloides) on the under side of some of the segments (in a few species without tyloides); branches of penis incompletely fused, the apical portion of the penis consisting of two pointed or curved rods or tongs.

The species of this group build, as a rule, aërial nests, either freely suspended at some height or close to the ground in bushes. Exceptionally the nest is almost subterranean.

8. *Vespula maculata* (Linnaeus).

*Vespula maculata* Linnaeus, 1763, Cent. Insect. Rar., p. 30 (no sex; Pennsylvania). Not *Vespula maculata* Scopoli, 1763; nor of Drury, 1773.

*Vespula maculata americana* Christ, 1791, Naturgesch. Insekt. vom Bienen, Wespen und Ameisengeschl., p. 239 (no sex; North America).

*V. maculata*, the bald-faced wasp or black hornet, is the most widely spread of all North American Vespinae. It occurs across the Continent, between 53° and 28° Lat. N., being especially common in the wooded areas of the Lower Austral, Upper Austral and Transition Zones. East of the Mississippi it is fairly uniformly distributed; but west of the Great Plains, it is found almost exclusively in the Transition Zone of the mountains.

I have seen specimens from Ontario, Nova Scotia, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Washington, D. C., Virginia, North Carolina, Georgia, Florida (Gainesville), Louisiana, Texas, Tennessee, Ohio, Indiana, Michigan, Wisconsin, Illinois, Missouri, Nebraska (Omaha), Iowa, Minnesota, North Dakota (Grand Forks), Colorado (several localities), Arizona (Patagonia Mts.), New Mexico (Jemez Springs),



Utah, Idaho, Washington State, Oregon, and California. There are also reliable records from Vancouver Island, Quebec, and Kansas. It occurs almost certainly in West Virginia, South Carolina, Alabama, Mississippi, Kentucky, South Dakota, Montana, Wyoming, and Nevada; and it should be looked for in northern Mexico. R. du Buysson's record from the "Antilles" was certainly based either on an error in labelling or on a specimen accidentally carried from North America.

*Vespula maculata* is the North American representative of the Palearctic *Vespula media* (Retzius), which, although very different in coloration, is extremely similar morphologically. After a careful comparison, I find merely some slight differences in the male genitalia (shape of the two apical branches of the penis), in the male antennae, and possibly in the seventh sternite. But I am not yet convinced that these differences are constant and of specific value. The true *V. media* does not occur in North America, all published American records being based upon erroneous identifications.

Regarding the type of *V. maculata*, in Linnaeus' collection at the Linnean Society of London, Mr. Robert B. Benson writes me: "The label has been transferred to a new specimen by Smith. There are three old specimens, one female and two workers. I do not know which of these is to be regarded as the type."

Several accounts of the habits of *V. maculata* have been published, notably by I. Mauduit (1756), B. D. Walsh and C. V. Riley (1869), W. Couper (1870), G. W. Taylor (1884), H. C. McCook (1885), J. L. Zabriskie (1894), T. W. Fyles (1903), L. O. Howard (1915), P. and N. Rau (1918), C. Macnamara (1918), W. T. Davis (1919), J. B. Parker (1928), P. Rau (1929), and others. The nests are always aërial, most often hung up on the limbs of trees, high above the ground; occasionally they are found under the roof or eaves of buildings. They frequently are very large, reaching a foot or more in diameter. In a newly started nest, the envelope is usually extended downward, beyond the nest proper, into a hollow tube, about one-half inch in diameter and two and one-half inches long. This "neck" is removed as the colony grows. One of the earliest figures of such a young nest is that by H. C. McCook (1885, p. 445, fig. 140). The ichneumonid parasite, *Sphécophaga burra* (Cresson) (= *Sphécophagus praedator* Zabriskie), has been bred from the cells of this species. The adult wasps are occasionally caught by the robber flies, *Proctacanthus philadelphicus* Macquart, *P. nigriventris* Macquart, *P. rufus* Williston, and *Mallophora orcina*

Wiedemann (W. T. Davis, 1919; S. W. Bromley, 1931). As shown by J. B. Parker (1928) and P. Rau (1929), in the nests of *V. maculata* the cells are used over several times, as many as five larvae being sometimes reared in succession in the same cell.

9. *Vespula arenaria* (Fabricius).

*Vespa arenaria* Fabricius, 1775, Syst. Entom., p. 365 (no sex; America). Not of most American writers.

*Vespa (Dolichovespula) arenaria* J. Bequaert, 1928, Bull. Brooklyn Ent. Soc., XXIII, p. 54 (♀; holotype).

*Vespa borealis* W. Kirby, 1837, Fauna Boreali-Americana, IV, p. 264 (no sex; boreal North America in Lat. 65°). Not *Vespa borealis* Zetterstedt, 1840; F. Smith, 1843; Lewis, 1897.

*Vespa diabolica* H. de Saussure, 1853, Et. Fam. Vesp., II, p. 138 (♀ ♀; North America).

The identity of *V. arenaria* with *V. diabolica* has been settled through a study of Fabricius' type, which I have seen in the Banks' Collection at the British Museum. The type of *Vespa borealis* Kirby appears to be lost. R. du Buysson (1905) believed that Kirby's description was based upon North American specimens of *Vespula norwegica* (Fabricius) and I had accepted this conclusion in 1920. After a more careful study of Kirby's original account, I now believe that he most likely had before him *Vespula arenaria*. He describes the clypeus as being yellow with a black floriform discoidal spot, the external orbits as yellow, the abdomen with two black dots on the segments except the first, and the middle part of the black basal bands of the abdomen projecting into a triangular tooth. These statements apply only to *V. arenaria* among the wasps of boreal North America.

*V. arenaria* is possibly the most widely distributed of all Nearctic yellow-jackets. It extends across the Continent between 32° and 67° Lat. N.<sup>11</sup> It is perhaps most abundant in the Transition Zone. In the Rockies it has been taken as high up as 10,500 ft., though it probably does not nest above 9,000 ft. I have seen the typical form (without yellow spots on the propodeum) from Alaska (northernmost locality: Fort Yukon, on the Arctic Circle), North West Territory (Good Hope on the Mackenzie River), British

<sup>11</sup> J. M. Jones' record of *V. vulgaris* from the Bermudas (1876, The Visitor's Guide to Bermuda, p. 142) was based upon specimens of *V. arenaria*. In recent years, however, no yellow-jackets have been taken in those islands, where *V. arenaria* was evidently introduced by man at one time (See J. Bequaert, 1929).

Columbia, Vancouver Island, Alberta, Manitoba, Ontario, Quebec, Anticosti, Nova Scotia, Maine, New Hampshire, Vermont, Massachusetts (said to be the only Vespinae in Nantucket), Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, North Carolina, Georgia, Michigan, Wisconsin, Minnesota, North Dakota (Fargo; Grand Forks; Langdon), South Dakota (Black Hills), Montana, Wyoming, Colorado, New Mexico (Cloudcroft; Las Vegas; Jemez Springs), California (Stanford University; Areata; San Francisco; S. Sonoma Co.; San Mateo Co.; Dixon), and Oregon. There are reliable records from Hudson's Bay, Newfoundland, Kansas (Douglas Co.), Arkansas (Fayetteville), and Arizona (Oak Creek, Coconino Co.). It most probably occurs also in the remainder of the United States, with the possible exception of Florida. Very likely it enters the Sierra Madre in Northern Mexico.

Structurally *V. arenaria* is exceedingly close to *V. norwegica* (Fabricius), and I am by no means certain that these two wasps are specifically distinct. In the queen and worker the anterior margin of the clypeus is much more deeply curved inward in *V. arenaria* than in *V. norwegica*, so that the lateral edges form more prominent, broadly rounded lobes. The difference is only of degree and difficult to describe, yet obvious when comparing the two species. The shape of the valva externa and penis of the male shows some slight differences as indicated in the key (compare Fig. 6A and 6D). *V. arenaria* is strictly Nearctic, while *V. norwegica* is Holarctic.

Most of the nests of *V. arenaria* I have seen, were placed close to the ground in high grass, low bushes, or shrubs, and were partly supported by twigs or brambles and grass-stalks. One nest, found in Vermont, was about 5 cm. above the ground, but another, dug up in the Adirondacks, on July 19, 1920, was attached to a root just below the surface, the outside cover being partly exposed. O. A. Stevens, in North Dakota, reports finding nests in trees and under the eaves of houses. W. M. Wheeler and L. H. Taylor (1921), in Connecticut and Massachusetts, found the nests mostly near the ground, occasionally in small trees or under roofs. They record an interesting observation of workers building a new nest, in the absence of the queen. They also found that *Vespula adulterina* var. *arctica* Rohwer is an inquiline in the nest of *V. arenaria*. Whether *V. arenaria* ever builds its nest actually underground or inside old stumps or logs, as Ashmead states, appears open to ques-

tion. H. B. Hungerford (1930) describes and figures a rather unusual nest of this species found in a log cabin in Michigan.

9a. *Vespula arenaria* var. *fernaldi* (Lewis).

*Vespa fernaldi* Lewis, 1897, Trans. Amer. Ent. Soc., XXIV, pp. 171 and 173 (♀ ♀; Colorado).

This is merely a xanthic variation of *V. arenaria*, especially notable for the presence of two yellow spots on the propodeum. As recently shown by C. D. Duncan (1924, Pan-Pacific Entomologist, I, pp. 40-42), one finds every conceivable intergradation between typical *arenaria* and *fernaldi*, and, in addition, the two

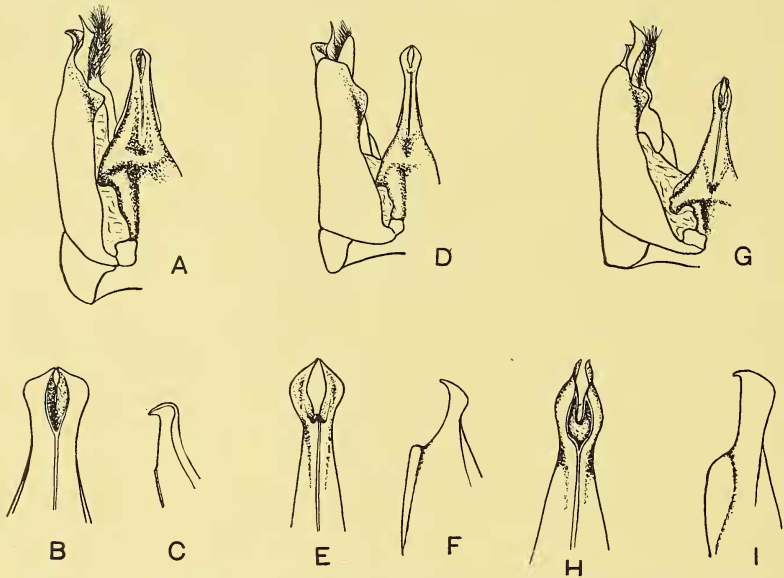


Fig. 6. A-C, *Vespula arenaria* (Fabricius): A, male external genitalia in dorsal view; B, apical branches of penis, much enlarged; C, the same in profile. D-F, *Vespula norvegica* var. *norvegicoides* (Sladen): D, male external genitalia in dorsal view; E, apical branches of penis, much enlarged; F, the same in profile. G-I, *Vespula adulterina* var. *arctica* Rohwer: G, male external genitalia in dorsal view; H, apical branches of penis, much enlarged; I, the same in profile.

forms occur promiscuously in the same nests. Duncan proposes to suppress *fernaldi* altogether. I believe, however, that there is some justification for retaining the name. Xanthic specimens are found throughout the range of *V. arenaria*; but, while they are rarely seen in the eastern United States, they are frequent in the Rocky



Mountains and on the Pacific Coast. In these western areas, the var. *fernaldi* shows a tendency to become the dominant form and might well eventually take the place of the typical *arenaria*.

I have seen eastern specimens of the var. *fernaldi* from Ontario (Gull Lake, 1 ♀; North Bay, 1 ♀), New York (Caroline-Harford, 1 ♀; Ithaca 1 ♀ and 1 ♂; Labrador Lake, Cortland Co., 1 ♀), North Carolina (Swannanoa, 1 ♀; Black Mountains, 1 ♀), Virginia (1 ♀), and Tennessee (1 ♀); also many western specimens from Alberta, British Columbia, Washington State, Oregon, California (much more common than typical *arenaria*), Idaho, Nevada, Arizona (Mt. Lemon, Sta. Catalina Mts.; Huachuca Mts.), Utah, Wyoming, Colorado, and New Mexico.

10. *Vespula norwegica* (Fabricius).

*Vespa norwegica* Fabricius, 1781, Species Insect., I, p. 460 (no sex; Norway).

*Vespa britannica* Leach, 1814, Zoological Miscellany, I, p. 111, Pl. L, figs. 1-3 (♀ ♀ ♂; England).

*Vespa borealis* Zetterstedt, 1840, Insecta Lapponica Descripta, p. 454 (♀; Lapland and Scandinavia). Not *Vespa borealis* W. Kirby, 1837.

*Vespa saxonica* var. *arctica* Friese, 1919, Mém. Ac. Sci. Russie, (8) XXVIII, No. 15, p. 1 (♀ ♂; several localities in northwestern Siberia). Not *Vespula arctica* Rohwer, 1916.

The above synonymy refers to the typical form only.

*V. norwegica* occurs throughout the Holarctic Realm in a number of color forms:

(1). Typical *V. norwegica* has, in the worker and male, rufous spots on the sides of the second or second and first abdominal tergites, in addition to the usual yellow markings. The queen, however, rarely shows these rufous spots, but, as a rule, is black and yellow only, even when found in a nest containing only workers and males marked with rufous. This form is strictly Palearctic and probably occurs over most of Europe and Siberia. It has so often been confused with the var. *saxonica* that it is difficult at present to trace its exact distribution. It extends northward beyond the Arctic Circle. I have seen it from England, Belgium, Germany, France, Switzerland, Finland, Sweden, and Lapland. I regard *Vespa borealis* Zetterstedt (1840, Insecta Lapponica Descripta, p. 454; ♀), *Vespa britannica* Leach (1814, Zoolog. Miscell., I, p. 111, Pl. L, figs. 1-3; ♀ ♀ ♂), and *Vespa saxonica* var. *arctica*



Friese (1919, Mém. Ac. Sc. Russie, (8) XXVIII, No. 15, p. 2; ♀ ♂) as not separable from typical *V. norwegica*.

(2). *V. norwegica* var. *monticola* Birula, a form richly marked with yellow, from the Caucasus Mountains, may be worth distinguishing by name.

(3). *V. norwegica* var. *saxonica* (Fabricius) differs from the typical form chiefly in lacking the rufous abdominal spots in the worker and male, as well as in the queen. I regard this form also as strictly Palearctic. Possibly it is found mainly in Western and Central Europe, and is perhaps of more southern distribution than typical *norwegica*. In many localities, however, the two forms occur together, nesting apparently under exactly the same ecological conditions. I have seen the var. *saxonica* from Germany and Sweden. *Vespa sexcincta* Panzer (1799, Faun. Insect. Germ. Init., VI, pt. 63, Pl. I), *Vespa bavarica* Schrank (1802, Fauna Boica, II, 2, p. 350; probably ♀), and *Vespa tridens* Schenck (1853, Jahrb. Ver. Naturk. Nassau, IX, 1, pp. 18, 19, and 38; ♀ ♂ ♂) are, in my opinion, synonyms of the var. *saxonica*.

(4). *V. norwegica* var. *pacifica* Birula (1930). This name has recently been proposed for the wasps of the Pacific Coast of Siberia and the neighboring islands, which R. du Buysson referred to the var. *marginata* (W. Kirby). According to Birula, they differ, however, from the American var. *marginata* in that the workers and males, as well as the queens, always lack the rufous spots of the second abdominal tergite. In this respect they agree with the var. *saxonica*, from which they may be told by the creamy-white or ivory-white, instead of bright yellow, pale markings of the body. I have seen, at the U. S. National Museum, a queen from Sakhalin and another from Kamchatka, received from Birula under the name *V. norwegica pacifica*.

(5). *V. norwegica* var. *norvegicoides* (Sladen). North America.

(6). *V. norwegica* var. *marginata* (W. Kirby). Boreal North America.

10a. *Vespula norwegica* var. *norvegicoides* (Sladen).

*Vespula norvegicoides* Sladen, 1918, Ottawa Naturalist, XXXII, p. 71 (♀ ♂; Nova Scotia to British Columbia).

This form has usually been called *Vespa norwegica* in American collections and writings. It differs from typical *norwegica* in lacking rufous abdominal spots in the worker and male, as well as in the queen. It is therefore very similar to the Palearctic var. *sax-*

*onica*, and it might even be questioned whether or not it is useful to retain these two varieties as distinct. All European *saxonica* I have seen appear to be more extensively marked with yellow than even the brightest North American *norvegicoides*, although the difference is more marked in the worker and male than in the queen. In *saxonica*, the yellow bands of the abdomen are, as a rule, very wide and the postscutellum is often spotted with yellow.

*V. n.* var. *norvegicoides* appears to be a wasp of the Canadian Zone of the North American Continent. In the Hudsonian Zone it seems to be replaced by *V. n.* var. *marginata*, while in the Transition Zone *V. arenaria* takes its place. I have seen it from southern Alaska (as far north as Anchorage, in about 61° Lat. N.), British Columbia, Vancouver Island, Alberta, Manitoba, Newfoundland, Nova Scotia, Maine, New Hampshire, Vermont, Massachusetts, Connecticut (Colebrook), New York (Adirondacks; Catskills), Virginia (Peaks of Otter), North Carolina (Mt. Mitchell; Black Mountains), Minnesota (Burntside Lake, St. Louis Co.; Beaver Dam, Cook Co.), Wyoming, Colorado, New Mexico (Pecos), Utah, Oregon, and Washington State. I have formerly recorded *V. norwegica* from Point Barrow, Alaska, north of 70° Lat. N., but I am no longer certain of the identification of this specimen, which I was not able to examine again. I suspect that it belonged to the var. *marginata*.

A nest of *norvegicoides* which I examined at Chittenden, Vermont, was placed in a dense thicket of brambles. It was attached to a twig, some 10 cm. above the ground, and was irregularly spherical. The entrance was on the under side of the nest, facing the ground. The colonies of this wasp are generally small. In the nest mentioned I found about 50 workers, in addition to the queen, on August 6. No males had yet hatched. In the Adirondacks, however, I have taken males as early as July 19.

10b. *Vespula norwegica* var. *marginata* (Kirby).

*Vespa marginata* W. Kirby, 1837, Fauna Boreali-Americana, IV, p. 265, Pl. VI, fig. 2 (described as ♀, but evidently ♀; boreal North America: "taken in the route from New York and again in Lat. 65°").

*Vespa norwegica* var. *marginata* R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, 4, (1904), p. 599 (♀ ♀ ♂).

*Vespa peruana* H. de Saussure, 1868, Reise d. Novara, Zool., II, 1, Hym., p. 18 (♂; Quito, Peru; this locality was undoubtedly based upon an error in labelling.

R. du Buysson saw one of the types, apparently received from de Saussure, and recognized that it was *V. marginata* Kirby).

*Vespa albida* Sladen, 1918, Ottawa Naturalist, XXXII, p. 71 (♀ ♂; Alaska).

The var. *marginata* has the pale markings of the body ivory-white or creamy-white instead of bright yellow, and the second abdominal tergite often bears a rufous spot on each side; the legs are more or less reddish. The rufous spots are rarely absent in the worker and male; but I have never seen them in the queen. In color the var. *marginata* copies exactly *V. rufa* var. *intermedia* (R. du Buysson), which occupies the same habitat, but is much rarer. These two wasps offer an excellent example of "regional convergence," or the tendency, so common in the Diptera, of different structural species to exhibit parallel color variation in the same region. By the protagonists of "mimicry" these cases would, I suppose, be regarded as "synaposematic" resemblances, that is of advantage as a protection against some mutual predacious enemy, who, after having been warned away by the sting of one or more of them, would learn to avoid them all as a group. I doubt, however, whether such is their true significance.

*V. n. marginata* is typical of the Hudsonian Zone of Boreal North America, although it has been found also at a few points well within the Arctic Zone. I have seen specimens from the following localities: ALASKA: Iditarod, 2 ♀, July 22, 1918 (Alice Twitchell); Mt. Haystack, Eschscholtz Peninsula, 1 ♂ and 1 ♀, Sept. 5, 1922 (L. J. Palmer); Noorvik and Kiana, Kobuk River, 1 ♀, 1 ♀ and 3 ♂, July 1923 (L. J. Palmer); Kadiak, 1 ♀, July 1899 (T. Kincaid); Kukak Bay, 3 ♀, July 1899 (T. Kincaid); in Long. 141°, Lat. 69° 20', 2 ♀ and 4 ♀, July 1912 (J. M. Jessup); Yukon River, 1 ♀ (Harrington); Healy, 3 ♀, June 23, 1924 (J. M. Aldrich); Rampart House, 1 ♀, June 1-6, 1912 (J. M. Jessup); Savonoski, Naknek Lake, 1 ♀, July 11, 1919 (A. J. Besinger), and 1 ♀, 5 ♀ and 3 ♂, Aug. 8, 1919 (J. S. Hine); Alfred Creek, 1 ♀, July 16, 1922 (R. L. Pope); Kutlik, 62° 30' N., 163° W., 1 ♀ (Dall); Katmai, 4 ♀, June 10, 1919 (J. S. Hine); Bethel, Kuskokwim River, 2 ♀ (Ac. Nat. Sci. Phila.) and 1 ♀, July 24, 1922 (L. J. Palmer); Teller (F. Johansen).—LABRADOR: Nain and Rama, several ♀ and ♂ (H. Stecker and J. D. Sornborger); Caribou Island, Straits of Belle Isle, several ♀ (A. S. Packard).

There are also reliable records from the Yukon Territory, but I doubt the occurrence of the var. *marginata* in British Columbia.

Lewis' statement that it occurs in New York State is based upon a misunderstanding of Kirby's text, while the specimen which he describes from Orono, Maine, is clearly not *marginata*, but *norvegicoides*. I have never yet seen a specimen of the true var. *marginata* from within the borders of the United States.

R. du Buysson also referred to the var. *marginata* specimens from Sikkim, the Island of Sakhalin, Japan (near Tokio), and Western Siberia (Altai). Those from Sakhalin and Altai were undoubtedly *V. n.* var. *pacifica* Birula, as indicated above. The correct status of the specimens from Sikkim and Japan must, however, be left in abeyance.

*V. n.* var. *marginata* nests underground. The workers from Caribou Island, Labrador, listed above, were referred to *V. norwegica* by Packard (1870, Trans. Chicago Ac. Sci., II, p. 26, Pl. II, figs. 7, 8, 15 and 17). They are now at the Mus. Comp. Zoöl., Cambridge, Mass., where I have seen them. Referring to this wasp, Packard wrote: "It builds its nest underground, and the one observed was about five inches in diameter. The members of the colony, on being disturbed, seemed unusually sluggish and indisposed to sting, compared with our New England species." Sladen (1919, Report Canadian Arctic Expedition, III, Insects, Part G, p. 26 G) mentions one queen and 26 workers taken by F. Johansen at Teller, Alaska, July 26, 1913. "The nest contained larvæ and was in a hole under an old willow shrub at the brink of the lake. The nest was half hidden in the hole, half protruding from it and attached to the thick root of the willows, while heather twigs supported the outer layers of the nest."

#### 11. *Vespula adulterina* (R. du Buysson).

In 1905, R. du Buysson described a var. *adulterina* of *Vespula norwegica*, which, he said, showed the same relationship to *V. norwegica* as *V. austriaca* does to *V. rufa*. He based his description upon a few females from Europe and one female from Corvallis, Oregon. For a long time this form was a puzzle to me. When I came to study a series supposedly of *V. arctica* Rohwer, from the Pacific Coast, I noticed that some of these specimens showed an evident tendency to be more abundantly marked with yellow, instead of with white. Some of the females from Oregon fit the description of *adulterina* to a nicety. As I have been unable to discover structural differences between these females (and their corresponding males) and specimens of *V. arctica* Rohwer, from the eastern United States, I believe that they all belong to one species



which should bear the earlier name, *Vespula adulterina* (R. du Buysson).

*V. adulterina* and its var. *arctica* are inquilines or social parasites, which lack the worker phase and have their brood reared by other social species of *Vespula*. They are, in the subgenus *Dolichovespula*, the exact counterpart of *V. austriaca* (Panzer) in the subgenus *Vespula*, proper. *V. adulterina* is evidently an offshoot of the *V. norwegica* stock, but the structural differences which separate it from that species are fully as pronounced as those found between *V. rufa* and *V. austriaca*. The following descriptions include the structural characters of both sexes, and apply to the typical form, as well as to the var. *arctica*.

*Female*.—Clypeus about as wide as long, with strongly projecting, median, truncate anterior margin, the edges of which form strong, triangular, blunt teeth, distinctly raised and directed outwardly; between the edges the clypeus slants strongly downward and the apical margin is deeply but evenly curved inward. Disk of the clypeus and interantennal area more convex than in either *V. arenaria* or *V. norwegica*. Oculo-malar space moderately long, about one and one-fourth times the length of the last, and one and one-half times that of the penultimate antennal segment, about two-thirds the width of the mandibular articulation, and about half the length of the antennal scape. Eyes nearly as far apart on the vertex as at the clypeus. Ocelli in a slightly flattened triangle; the posterior pair placed on the imaginary line traced over the vertex between the posterior orbits, and nearly twice as far from the eyes as from the occipital margin. Outer orbits about as wide as the eye in profile, without a distinct carina or suture dividing it from the occiput (very rarely with a trace of suture along the upper third). Third segment of labial palpi with a minute seta before the apex on the inner side. Anterior vertical carina of pronotum well marked, complete, gradually disappearing above the coxa; postero-lateral margin of pronotum not carinate, preceded by a fine suture. First abdominal tergite short and wide, very evenly rounded off between the anterior, vertical face and the posterior, horizontal area; the latter about three and one-half times as wide as long, scarcely narrower than, and about half the length of, the second tergite. All tibiæ with numerous, long, erect hairs on the outer side. Puncturation moderately abundant, as usual; no striation on sides of pronotum nor on propodeum; disk of clypeus with very few, much spaced, large punctures. Hairs of the body



long, erect, abundant, mostly gray, mixed with black on the vertex, dorsum and first tergite.

*Male*.—Clypeus markedly wider than long; the median, truncate, anterior margin moderately projecting (less so than in the female, but distinctly more than in the male of *V. arenaria*), with blunt, broadly rounded edges, which are very slightly raised, the anterior margin between them faintly curved inward. Oculo-malar space longer than in the female, about five-sixths of the length of the antennal scape, a little longer than the penultimate, but much shorter than the last antennal segment. Eyes a little farther apart on the vertex than at the clypeus. Posterior orbit at most with a trace of a suture near the occiput. Flagellum of antennæ without tyloides or longitudinal welts on the under side; the last segment only with a faint trace of a longitudinal welt near the base. Seventh abdominal tergite evenly convex throughout, its apical margin broadly rounded; seventh sternite broadly rounded, entire. Genitalia: branches of penis incompletely fused; shaft, seen from above, broadly triangular at the base, gradually tapering to the apex, which consists of two slender rods, somewhat widened basally, very narrow apically, and hardly curved toward each other; in profile, the median portion of the shaft bears a dorsal crest and the two end pieces are shaped like a hawk's bill, with the short point directed upward; stipes of valva externa broadly truncate and rounded at apex, the upper inner edge (seen from above) very blunt and slightly projecting, the squama broadly triangular and ending in a long, sharp point; volsella of valva interna short, elongate spoon-shaped at the tip, which is fringed with short hairs.

*V. adulterina* is readily distinguished from either *V. arenaria* or *V. norwegica* by the peculiar shape of the clypeus, the different relative length of the oculo-malar space, and the absence of a distinct ridge dividing the upper part of the outer orbit from the occiput. It is rather noteworthy that the prominent edges of the clypeus are likewise characteristic of *V. austriaca* in the subgenus *Vespula*, proper. Although it is difficult to correlate this structural peculiarity with the parasitic habits of these two species, yet the same factors must have been responsible for its appearance in both cases.

*V. adulterina* probably occurs sporadically throughout the Holarctic Realm, much in the same fashion as *V. austriaca*. Its apparent rarity in the Palearctic Region must be due to its being overlooked in collections and confused with *V. norwegica*. In the

Nearctic Region the species extends across the Continent, but apparently is restricted to the Canadian and Transition Zones.

In Europe and Asia, *V. adullerina* is known only in the typical form, which has very extensive pale markings, varying from dirty-yellowish or ivory-white to pure yellow (nearest Ridgway's picric yellow). In North America, this xanthic form occurs in the Pacific States only, where one finds occasionally specimens in which the yellow is very bright; in most cases, however, the markings fade to ivory-white or dirty-white, although even then they are usually much more extensive than in the eastern specimens. I do not therefore base the distinction between typical *adullerina* and its var. *artica* upon the *tint* of the color markings, but rather upon their *extent*. East of the Mississippi, *V. adullerina* is always marked with white, and, as a rule, the markings are much reduced. These eastern specimens have thus far been known as *V. borealis* Lewis or *V. artica* Rohwer; but they represent, in my opinion, the melanistic color form of *V. adullerina*. Transitions in extent of color occasionally occur between typical *adullerina* and its var. *artica*, especially west of the Mississippi, where both forms are found. If for the present I keep them distinct, it is because names are available and because I have never seen eastern specimens with yellow or even yellowish markings. Moreover, the white var. *artica* is not known from the Palearctic Region.

11a. *Vespula adullerina*, typical form.

*Vespa norvegica* var. *adullerina* R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, (1904), pp. 600 and 628 (♀; Piedmont; Remiremont, Vosges, France; Rosegthal, Engadine, Switzerland; Corvallis, Oregon).

*Vespa saxonica* var. *adullerina* Bischoff, 1927, Biologie der Hymenopteren, p. 404 (suggests that it is a distinct species, parasitic upon *V. saxonica*).

*Vespa adullerina* Bischoff, 1931, Mitt. Deutsch. Ent. Ges., II, p. 6 (♀ ♂).

*Pseudovespa adullerina* Bischoff, 1931, Sitzungsber. Ges. Naturf. Fr. Berlin, (1930), pp. 330-334, figs. (in part) 1, 3, 4, and 5 (♀ ♂).

*Vespula norvegica saxonica natio colchica* Birula, 1930, Ann. Mus. Zool. Ac. Sci. U. R. S. S., XXXI, 2, p. 314 [♂; "Adsharian (Batum-Gebiet, Alpenwiesen, s. g. Jailag, bei Sarytschaur auf der Höhe von etwa 2300 m. ü. d. M.)"].

My conclusion that *V. adullerina* is a distinct, inquiline species, was reached independently from Bischoff. It was based at first

upon the evident relationship of this wasp with *V. arctica* Rohwer and upon the parallelism in certain structural characters exhibited by *V. adullerina* and *V. austriaca*. That typical *V. adullerina*, in North America, has true parasitic habits was demonstrated by a recent find of Professor H. A. Scullen in Oregon. After killing with carbon disulphide a colony of *Vespula arenaria* var. *fernaldi*, at Crater Lake Park, he found among the contents two males of *V. adullerina*. In Europe, Bischoff reports that M. Müller caught a female of *V. adullerina* as it flew out of a nest of *V. norwegica*.

I have seen typical *adullerina* from the following localities: BRITISH COLUMBIA: Downie Creek, Selkirk Mts., 1 ♂; Ground Hog Basin, Big Bend Country, Selkirk Mts., 1 ♂ (J. C. Bradley).—ALBERTA: Banff (Owen Bryant).—VANCOUVER ISLAND: 1 ♀ (Am. Mus. Nat. Hist.).—WASHINGTON STATE: Paradise Valley, Mt. Rainier, 2 ♀ and 1 ♂ (E. C. Van Dyke); Mt. Olympic, 1 ♂ (Darlington).—OREGON: Clatskanie (H. A. Scullen); Cloud Cap Inn to Elk Cove, Mt. Hood, 6,000 ft. (H. A. Scullen); Eagle Ridge, Klamath Lake, 4 ♀ (C. L. Fox); Crater Lake Park, 6,500 to 7,000 ft., 16 ♂ (H. A. Scullen); Mary's Peak (H. A. Scullen); Mt. Hood, 1 ♀ and 1 ♂.—CALIFORNIA: Alta Meadow, 8,000 ft., 2 ♂ (W. M. Wheeler); Nash Mine, Trinity Co., 1 ♀ (E. C. Van Dyke); Giant Forest, Sequoia National Park, 1 ♀ (R. C. Shannon); Gold Lake, Sierra Co., 1 ♀ (C. L. Fox).—IDAHO: Beaver Canyon (L. Bruner); Moscow; Craigs Mt., 1 ♀; Priest Lake, 1 ♂.—WYOMING: Yellowstone National Park, 1 ♀ (R. C. Osburn).—UTAH: 2 ♂ (Ac. Nat. Sci. Phila.); Bear Lake Valley, West Side, 1 ♀ (C. Lynn Hayward).—COLORADO: Mill Gulch, 1 ♀; Chimney Gulch, Golden, 4 ♂ (Oslar); Copeland Park, Boulder Co., 1 ♂ (S. A. Rohwer); Longs Peak Inn, 9,900 ft., 1 ♀ (E. C. Van Dyke); Manitou, 1 ♀ (E. C. Van Dyke).

In addition to the localities listed with the original description, R. du Buysson also recorded specimens from Mongolia, the Island of Sakhalin, and the village of Lasevo near Viterbsk (western Russia). Possibly some of these specimens may have been one of the color forms of *V. norwegica*. On the other hand, Birula's description of the male for which he proposed the name *colchica*, agrees quite well with some of my specimens of typical *adullerina*. At the U. S. National Museum I have also seen a female of *V. adullerina*, from the Govt. Petropolis (Leningrad), sent by Birula under the name *V. norwegica* var. *ornata* Birula, a vocable which, so far as I can trace, has not yet been used in print in connection with a description.

11b. *Vespula adulterina* var. *arctica* Rohwer.

*Vespula* (*Dolichovespula*) *arctica* Rohwer, 1916, in Viereck, Guide to the Insects of Connecticut, III, Hymenoptera, p. 642 (new name for *Vespa borealis* Lewis).

*Vespa borealis* Lewis, 1897, Trans. Amer. Ent. Soc., XXIV, pp. 171 and 174 (♀ ♂; New York; Mt. Washington; British Columbia; Amherst, Mass.). Not *Vespa borealis* W. Kirby, 1837.

The var. *arctica* is found across the North American Continent, but is much more common in the eastern parts. It is, however, the only form known from Alaska. I have seen it from the following States and Territories: Alaska (Seward; Skagway), British Columbia, Quebec (Val Morin; Montreal), Maine, New Hampshire, Massachusetts, Vermont, Connecticut, New York, New Jersey, Pennsylvania, Virginia, North Carolina (Valley of the Black Mountains; Mt. Mitchell, 6,700 ft.; Andrews Bald Mt., Swain Co.), Michigan, Minnesota (International Falls; Beaver Dam, Cook Co.; Burntside Lake, St. Louis Co.; Cramer), Colorado (Peaceful Valley; Long Lake, Boulder Co.), Wyoming (Douglas), and Montana (Washington Creek, Madison Co.).

*V. adulterina* var. *arctica* is an inquiline in the nest of *V. arenaria* (Fabricius) (= *diabolica* H. de Saussure), as was first observed by J. Fletcher near Ottawa, Canada (see 1908, Ann. Ent. Soc. America, I, p. 80). More recently, W. M. Wheeler and L. H. Taylor have made detailed observations of the relations between *arctica* and its host-wasp in Connecticut (1921, Psyche, XXVIII, pp. 135-144, Pls. VI-VII). They found that *arctica* is a permanent social parasite of *V. arenaria*, her brood, consisting exclusively of males and fertile females, being reared by the *arenaria* workers.

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